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Fig. 1.—Using a staybolt driver as holder-on where ordinary holder-on cannot be employed.

PROGRESS IN BOILER, TANK AND PLATE SHOPS.—[See page 68.]

Zinc Smelting in the Electric Furnace*

Commercial Superiority of the Electric Process Over the Older Methods

By Woolsey McA. Johnson

THE Johnson electric zinc furnace produces in one operation spelter, a fusible slag, copper matte and base-lead-bullion, whereas the retort plant produces spelter and an infusible residue or clinker. For success the Johnson furnace must produce a slag of maximum fluidity, but the retort furnace must produce a residue of maximum infusibility. Electric-furnace methods, when the use of electric current is properly understood, allow of any temperature or of any possible desired chemical condition.

In the retort process any slag-making material is a bugbear. In my earlier practice I used to divide the ores into two mixes, one "acid" and one "basic." I had the coals used for reducing materials analyzed so as to see that no coal with a fusible ash came into the works, as I did not care to have my retorts "gummed up."

At the Hartford demonstrating plant, at which I am now stationed, we have turned from the retort plant and are moving in a metallurgical direction as far away as is the West from the East. The mixes are prepared so as to make a slag as liquid as water. Instead of decrying lime in the ore, we desire lime in the zinc ores. Instead of penalizing iron in the ore, we need iron in the ore. Instead of refusing to purchase ore with fluorspar in it, we want fluorspar in zinc ore, for often we purchase gravel fluorspar to add to the zinc mix. Slag is not a bugbear, but a welcome friend to our process.

ELECTRIC SMELTING ALLOWS WIDE SLAG VARIATION.

In the electric steel furnace, the slag plays a different commercial rôle. This is a refining process. The Johnson process is a smelting process. The Heroult furnace is intermittent. The Johnson furnace is continuous. In the Heroult furnace, aided by three powerful 500-kilowatt arcs, they smelt a slag containing from 60 per cent to 70 per cent lime. This is so high in lime as to wash the steel practically free from sulphur and phosphorous. This high lime slag would not be possible to melt commercially save in an electric furnace. In the work in California, Norway and Sweden in iron-ore smelting, we see that the metallurgist can use a wide range of slags at his will, some high in lime, some high in magnesia, some high in silica.

If one will examine electric-furnace methods such as used at Niagara Falls, for example, one will be amazed at the potentialities. One will see definitely that any slag desired can be made; that it is not a question of chemistry but of business. We can make any slag we wish. What slag will make us the most money? This is all especially true of making ferro-vanadium, ferrochrome, ferromanganese and ferro-silicon in the electric furnace.

LIMITS OF ZINC SLAG.

In the Hartford electric zinc furnace there have been made a variety of slags. These slags are all tested in the Johnson slag tester for fluidity. The adjustment of electrodes as to slope, height, voltage, amperage, and the feeding of the charge all are a matter of careful science and practical metallurgy. I know that it is possible to reduce the percentage of zinc in the slag and to hold it there, or to raise it up again.

We have made and tested practically, say on one ton or more, or less, about one hundred different slags. These have had a wide range of analyses. Our laboratory and furnace records show a maximum and minimum:

	Maximum.	Minimum.
SiO_2	58.0%	18.2%
CaO	36.5%	3.5%
MgO	13.5	1.0
FeO	33.3	3.3
Zn	24.0	0.9
Al_2O_3	19.1	5.9

We even made one slag containing 6 per cent chlorine.

We can "knock out" the last percentages or traces of zinc if we please. The point is, "Will it pay to do it?" It is impossible to knock out the last traces of zinc in a retort furnace for the retorts would be butchered. In a retort plant, it is impossible to squeeze out the last part of the zinc so as to give a recovery without spoiling the furnace.

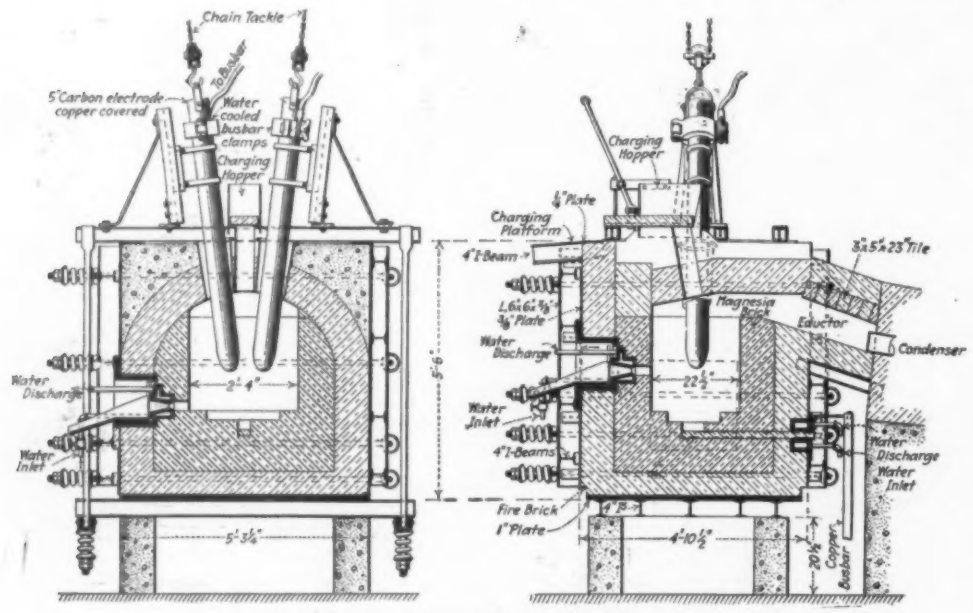
In the Hartford furnace, affairs are quite different, for with the help from some of the best known metallurgists in the world, we have a lining and a furnace that, in my opinion, will stand any slag at a temperature of 3,300 deg. Fahr., under the conditions peculiar to our operation. We operate our furnace at a temperature range of from 2,300 to 2,500 deg. Fahr.

We are now building our latest electric zinc furnace for making in one operation spelter, slag, copper matte, and lead-base bullion, the last two mentioned carrying the gold and silver contained, of a minimum capacity of three tons of roasted ore per 24 hours and a maximum capacity of five tons of roasted ore per 24 hours. It plans to build later a furnace of much larger capacity, say of 25 tons of roasted ore per 24 hours.

Suppose we treat in this a low-grade ore containing 28 per cent zinc and make 40 per cent slag. It is estimated that it will cost 70 cents to tap the furnace with a modern water-cooled bronze slag monkey and that we will tap slag twice every 24 hours. This cost with amount of other charges will be about as follows:

COST OF GETTING SLAG FROM FURNACE TO DUMP PER TON ROASTED ORE.

5-ton furnace, 2 tons slag	$0.40
10-ton furnace, 4 tons slag	0.30
25-ton furnace, 10 tons slag	0.25
50-ton furnace, 20 tons slag	0.22



Johnson Continuous Electric Zinc Furnace

* Reproduced from the *Engineering and Mining Journal*.

In a retort furnace handling eight tons of roasted ore, the cost of removing residues is about as follows, a blowout man, a bumper and a chiseler being needed. (As laborers all work together, it is hard to make an accurate distribution of costs, but the following is substantially accurate:)

RENEWAL OF RETORT RESIDUES, RETORTS TO DUMP.

Three-men days at $2.00	$6.00
Cleaning residues out of cellars	2.25
Total cost	$8.25
Cost per ton of roasted ore	1.03

A careful estimate of losses contained in the residues of a retort plant per ton of roasted ore gives 60 pounds zinc. This is based on residues analyzing 5 per cent zinc and on residues amounting to 60 per cent of weight of roasted ore, which, with spelter at 5 cents per pound, equals $3.

Commercial slags in the Johnson process have a probable maximum zinc percentage of 3 per cent, and probable minimum value of 1 per cent Zn with a probable average of 2 per cent Zn. Making slag weighing 40 per cent of weight of roasted ore we have a zinc loss in slag per ton of roasted ore of 16 pounds, or a money loss of 80 cents, with spelter at 5 cents.

ELECTRIC SMELTING GREATLY REDUCES REDUCTION FUEL.

Another advantage in the continuous zinc process is the decreased amount of coal used. In the continuous zinc furnace making spelter, slag, copper matte and lead-base bullion in one operation, only enough carbon is added to reduce properly the oxides desired to be reduced. In the retorting operation making spelter and residues a large excess is usually added. A retort plant uses 60 per cent coal, coke, anthracite or soft coal. Enough has to be added to furnish sufficient carbon to make the charge active and at the end of the intermittent operation to hold up the fusible impurities so that "pots will blow out clean." The Hartford demonstrating plant uses 15 per cent soft coal. Assuming the cost of coal to be the same in each process, $3 per short ton:

60 per cent coal at $3 is $1.80
15 per cent coal at $3 is $0.45

In a slagging operation the production of copper matte and base-lead bullion is at once unavoidable and desirable. This gives the plant having a continuous electric zinc furnace two important by-products directly salable to a lead-ore smelting plant or to a copper-ore smelting plant.

J. E. Johnson, Jr., consulting engineer and metallurgist, visited our plant during a run. In a report, among other things, he said: "The feature which impressed me most in connection with this plant was the absolute control under which it ran and the extreme steadiness of operation and freedom from interruption of all kinds.

"My understanding is that the presence of zinc in lead or copper ores is a serious detriment to their successful smelting, and that the presence of zinc is penalized by the buyers of such ores; also, that the presence of lead, copper, iron and lime are highly objectionable in zinc ores for use in a standared retort process.

"The working of the furnace when I was there convinced me that there was no technical difficulty in producing spelter and, simultaneously, slag, matte and metallic lead, which could be tapped from the hearth of the furnace as desired. This matter, like all other industrial matters, is purely a commercial one, and it would seem to me not difficult to demonstrate by tests that ores now useless or of low value on account of their complex nature can be so handled in your continuous electric furnace as to recover a large part of the value of all ingredients, thus giving you virtually the sum of their metallic values rather than the difference of the same, as is customary with present smelting methods."

This gives the point of difference exactly. In a properly developed electric zinc furnace, it is metallurgical addition, not subtraction.

Another point in the favor of slagging against the dry-residue proposition of the retort is that it takes less heat because of the fact that the final temperature is less and because the quantity of material to be heated is much less.

A rather remarkable feature is the phenomenonally

low percentage of copper, silver, lead and gold in the Hartford slags.

Slag analyzing as low as 0.01 per cent copper, 0.005 per cent lead, 0.05 ounces silver per short ton are not uncommon. In fact, they have been so low that a report copper "trace," lead "none," has been made several times.

From June 1st to 30th, 1913, 16.9 short tons of slag were made. An average (not, however, a weighted average) sample analyzed by us, gave Cu, 0.065 per cent, electrolytic assay on 5-gramme sample; Pb, 0.05 per cent, wet assay on 5-gramme sample; Zn, 5.25 per cent; Ag, 0.50 ounces per short ton on 2 a.t. sample; Au, 0.01 ounces per short ton on 4 a.t. sample.

This includes several taps in which poor settling occurred.

It can, therefore, be concluded that the Johnson electric zinc-furnace losses in values of copper, lead, gold and silver passing off into slag will be less than in lead-smelting plants and much less than the 15 to 25 per cent in the combined treatment or thereabouts in a retort plant.

It is, therefore, believed that in the respect of making a slag instead of a residue the zinc furnace has many points of advantage. Those that are directly seen are as follows:

Removing residue	$1.03	
Removing slag	0.30	
Saving	$0.73	$0.73
Zinc loss in retort plant	$3.00	
Zinc loss in electric plant	0.80	
	$2.20	2.20
Coal in retort plant	$1.80	
Electric smelting	0.45	
	$1.35	1.35
Total net differential advantage in slagging over retorting per ton of roasted ore		$4.28

The increased saving of by-product values such as gold, silver, copper and lead is greater than the above, but the indicated saving of $4.38 through specific advantages of electric zinc smelting is attractively large.

The Rise of Temperature Associated With the Melting of Icebergs*

By H. T. Barnes

It has been shown by means of microthermograms taken on a trip to Hudson's Straits that an iceberg melting in salt water produces a rise of temperature. The experiments were performed on the Canadian Government steamship "Stanley," and indicated that when approaching ice a rise of temperature occurred followed by a rapid fall of temperature a quarter of a mile abeam of the berg.

During the past summer I had an opportunity of examining in detail the temperature effects of icebergs. The Canadian Government placed their steamship "Montcalm" at my disposal for the tests, and three weeks were spent through the Straits of Belle Isle. Careful records were made of the temperature effects of icebergs and land. These tests have shown conclusively that it is the rise of temperature which is the direct action of the melting iceberg, and that when a fall of temperature is observed near ice it is due to the influence of a colder current from the north in which the iceberg is carried. The cooling influence of the ice itself is very small. Cooler currents exist in the main Arctic current, whether accompanied by ice or not, but the presence of the ice causes a zone of water of higher temperature to accumulate for a considerable distance about it.

The icebergs I studied in the Straits of Belle Isle and off the eastern end of the Straits in the Labrador current showed no cooling effect even within a few yards of them.

In Fig. 1 I show the isothermal lines about a typical berg off the eastern end of the Straits of Belle Isle. This diagram was obtained by arranging a number of courses for the ship from all sides up to the ice along radii of six miles.

As a good example of how icebergs and groups of icebergs affect the water temperature, I show a microthermogram in Fig. 2 taken from the records which were obtained in a westward passage through the Straits of Belle Isle. In every case the approach to ice caused a rise of temperature.

The explanation of this iceberg effect is founded on Pettersson's theory of ice melting in salt water. By this theory, which can easily be verified by a simple experiment, ice melting in salt water produces three currents: (1) a current of sea water cooled by the ice, which sinks downward by gravity; (2) a current of warm sea water moving toward the ice; (3) a current of light fresh water from the ice, which rises and spreads over the surface of the salt water.

I at first thought that it was this surface current of fresh water that influenced the microthermometer in the actual sea tests. The fringe of this lighter water would be warmer than the sea water on account of the action of the sun and scattered radiation, which is very strong at sea. The lighter water would retain the heat because it could not mix readily with the sea water. Near the iceberg I considered that a fall of temperature would result from the cooling influence of the surface current of fresher water.

My recent tests have shown, however, that an iceberg melts so slowly that no effect of the dilution can be detected even right beside the berg. I took a number of samples of sea water at different distances from the berg, as well as from places far from ice. These samples I carefully bottled and brought home to the laboratory, where they were most accurately tested by the electric conductivity method in our physico-chemical department by Dr. McIntosh and Mr. Otto Maass. The tests were carried out at a constant temperature in the most favorable circumstances, and there is no reason to doubt their correctness. Their comparison shows no dilution due to the icebergs, which goes to show how quickly the melted water from the berg is mixed with the sea water. Larger variations were found over different parts of the sea than were obtained in the proximity of ice.

My tests have shown that an iceberg probably causes only two of the Pettersson currents, i. e., a cold current sinking downward carrying with it all the melted ice water, and a horizontal surface current of sea water flowing in toward the ice to cause its melting (see Fig. 3). By this means we should expect the sea in the immediate proximity of icebergs to be warmer than farther away, because the sea surface current is moving toward the berg, and does not share in the normal vertical circulation which tends to keep the sea surface temperature cooler.

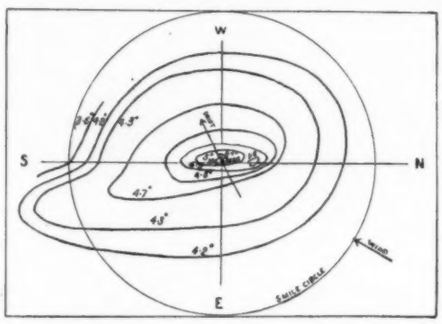


Fig. 1.—Isothermal lines around an iceberg.

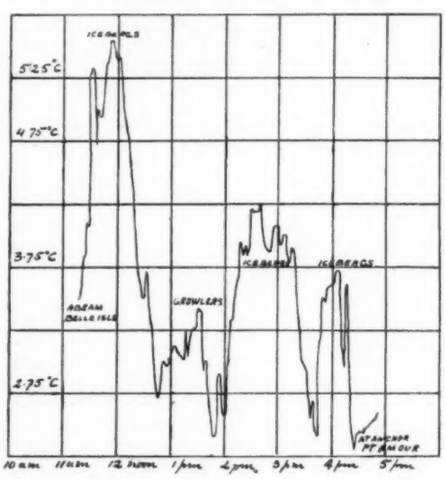


Fig. 2.—Microthermogram through the Straits of Belle Isle, showing the rise of temperature caused by ice.

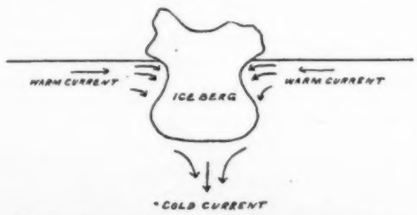


Fig. 3.—Convection currents due to iceberg melting. The fresh water from the melting berg is carried downward.

It is interesting to find that an iceberg causes its own current of warmer water, thus providing for its own destruction. Abundant evidence is at hand to show the melting process going on under the water-line.

DISSOLVED AIR.

In my observations of icebergs I was greatly struck with the large amount of dissolved air in the ice. The white color of the berg is due to innumerable air bubbles in the ice, and not to snow on the surface. An iceberg is very deceptive in this way. While it looks quite soft, the ice is so hard as to make it difficult to chop with an ax. The ice water which I prepared for drinking on board ship with iceberg ice effervesced like soda water, merely owing to the liberation of the air from the melting ice. It is possible that the sudden disappearance of bergs with a loud report is due to their explosion from accumulated air in the interior. One berg which I studied was casting off small pieces, apparently by the pressure of the pent-up air.

EFFECT OF LAND.

While icebergs send the temperature of the sea up, the coast line sends it down. I believe this to be due to the action of the land in turning up the colder under-water. My observations show this effect not only here, but on the English and Irish coasts.

From the point of view of the safety of our St. Lawrence route, the effect of land is most important. The iceberg causes us very little worry because we have only a very short ice track, but to find means whereby the presence of land can be determined is of the greatest importance. A full account of my experiments is being published by the Canadian Department of Marine.

* Reproduced from *Nature*.

International Conference on the Meter

The International Conference on the Meter has opened at the Ministry of Commerce, under the presidency of Prof. Appell, member of the Academy of Sciences. It has come to several important decisions; first of all, the delegates have verified the standard kilogrammes of the different countries adhering to the convention of the meter. Only the Danish, Hungarian and Servian kilogrammes have undergone important alterations. The kilogrammes of the other nations had not varied a hundred millionth of their weight, which would be a small error, equal to that which would be made if one made the mistake of the earth's meridian. The Conference has also decided that the States that possess geodesic bases shall exchange among themselves the Invar wires, so as to verify, very precisely, the length of these bases. Moreover, the standards with ends that are used to give the caliber to pieces of machinery will have a definition temperature equal to zero degrees. Thus in the whole world there will be one single scale for the construction of machinery. The Conference has foreseen the time when the temperature scales actually in use will be abandoned. The hydrogen thermometers are those by which low temperatures may be attained; temperatures of minus 252 degrees to minus 271 degrees, which is the temperature of the liquefaction of helium. Preparatory studies are soon to be undertaken in order to reach, in a near future, a scale of a still greater elasticity, that of thermodynamic temperatures.—*Chemical News.*

The Total Cube of the Water of the Earth

Prof. W. Halbfass reckons that the total cube of water of the terrestrial globe is 1,304,068,550 cubic kilometers. The greater part of this volume, that is to say 1,300,000,000 cubic kilometers, is in the oceans. Next in order of importance comes the quantity of water contained in the icy regions, especially the ice of the Poles, that is to say 3–5 millions of cubic kilometers. The lakes and ponds would contain 250,000 cubic kilometers, the subterranean waters a similar quantity, the rivers 50,000 cubic kilometers, atmospheric water 12,300, the marshes 6,000, and the snow on the surface of the ground 250,000 cubic kilometers. The total volume of the terrestrial globe being 1,083,205 millions of cubic kilometers, the volume of the waters is equal to 1/830 of the volume of the earth.—*Chemical News.*

Meteorological Stations in Tripolitania.—In accordance with the recommendations of the agricultural commission of the Italian colonial ministry, which has been investigating the resources of Italy's new African possessions, eleven meteorological stations have been established in Tripolitania, in addition to the observator at Tripoli.

Progress in Boiler, Tank and Plate Shops*

New Methods Introduced and Special Equipment Used in Well Organized Shops to Increase Output

By C. A. Tupper

It is a noteworthy fact that while every possible effort has been made toward improving the equipment of machine shops and increasing their operating economy, this gain has not been attended by corresponding progress in the work of the ordinary boiler, tank or plate shop, apart, of course, from the manufacture of large water-tube boilers and some of the high grade tubular boilers, which is a line of production in a class by itself.

Within the past year or two, however, a change has been observable in the attitude and methods of the men responsible for the operation of such shops, and many new ideas are being developed. Perhaps it is incorrect to say "new," for most of the ideas have heretofore been carried out somewhere; but the effect on the industry as a whole is the same. Recent tendency has been to gather up these isolated examples of improved methods and make them more general in their application. This is due, for the most part, to four principal causes, such as gatherings of superintendents and foremen at conventions, where experiences have been interchanged; exchange of visits among plants; suggestions made in the advertisements and printed matter of manufacturers of boiler shop equipment or carried from place to place by their salesmen, demonstrators, erectors and others, and the exigencies of repair work particularly in railroad shops.

The photographs reproduced herewith show applications of tools in locomotive boiler, firebox, tank and tender work, where some of the most ingenious, time-saving methods have been introduced. Fig. 1 (see our front page illustration) is an adaptation of a staybolt driver as a holder-on, for which purpose it drives up to the head of the rivet and is used in a position close to the sheet, to which an ordinary holder-on is not adapted. Fig. 2 shows a self-supporting device made on the same principle as the staybolt driver and pneumatic holder-on just referred to, and Fig. 3 illustrates its use in combination with an ordinary pneumatic hammer. Fig. 4 shows a special tool, which in this case is arranged for knocking off the heads of rivets from a firebox, the record made at the time the photograph was taken being 430 7/8-inch rivets per hour; and in Fig. 5 it is set for punching them out. Fig. 6 illustrates an adaptation of a somewhat similar tool for holding on and driving up mud drum rivets, and in Fig. 7 it is shown putting in firebox flue sheet rivets for an oil-burning engine, these rivets being driven flush with the inside. The same view displays a rivet buster attached to a yoke, as used for removing the burrs from wrapper sheets. A feature of this photograph is also the self-supporting crane, the jib of which is swung from a portable structural column and used for holding up the tool. This support can be set down anywhere by one of the shop cranes and used for holding up a great variety of pneumatic tools. Its base can be seen directly back of the operator.

This ingenuity in the use of small tools has been carried into larger work. At one of the principal heavy plate shops of the country the writer found many special devices. Spacing tables for accuracy and speed in punching large sheets are no longer a novelty; but at this plant there is one designed by the superintendent which is believed to be the largest of its kind and possesses a number of unique features. This is so constructed, with automatic adjustments, that a single operator is enabled to set, regulate the spacing and punching and otherwise handle the heaviest plate that can be put upon the table. Sheets weighing as much as 7,000 pounds have been punched here, and the one man assigned to the work has been ample for all requirements. At the time of the writer's visit this spacing table was arranged for punching out three notches, 2 x 6 inches, on each side of a heavy plate. Twelve binding bolt holes, 5/8 inch in diameter, were also to be punched, one on each side of the six notches. These plates, as it subsequently developed, were set, notched and punched on both sides of the sheet at a rate slightly in excess of 20 per hour. With this table the ordinary sawtooth rack movement is replaced by one involving a steel templet, which, together with its locking pins, will accurately space any layout within the scope of the table. These templets can, of course, be designed to cover an extremely wide range of work; they are quickly and accurately made and but little time is required to attach any templet to the table. The design and arrangement of the table are such that the only limit to the size of the plate to be punched is the room available in which to operate. For example, sheets 30 feet in length and ¾ inch thick that are punched for 7/8-inch rivets in one, two or four rows, can be handled as readily as the smaller sizes. The table is built almost entirely of structural shapes, the only cast iron used being the spreaders and stools for carrying the beams or rails. This style of construction not only gives a very light table, but also one of considerable flexibility, which will yield to the weight clamped upon it without impairing the accuracy of the work to be performed.

In numerous shops throughout the country a marked distinction is beginning to be made between the requirements of heavy, slow punching and those of light, quick work. For the latter purpose especially designed rapid production machines, capable of both regular and irregular punching, will soon be as common, relatively speaking, as tools serving similar purposes in machine shops. The same is true of bending rolls, straightening machines and shears, necessitating for the larger shops a more comprehensive line than formerly, although with these tools the distinction referred to has always been made to a greater extent than with the punching machines. In the speed and efficiency of each the arrangement of the drive, particularly by geared or direct-connected motor, has much to do.

For all cold-cutting outside of plate shearing an interesting development is the rapidly growing use of high-speed friction saws, the cutting blades of which are usually mounted directly on the shafts of motors especially designed for this class of work. This limits the speed to that of the motor, in each case, but by gearing the saws can be brought up to any speed. The method is coming more and more to be regarded as the most economical yet devised, both from the standpoints of speed and kerf and also of the effect on the material; so that it promises to become general.

On the subject of drilling operations in plate, tank and boiler shops an extended treatise might be written; but in general it may be said that machine shop methods are being everywhere successfully introduced, notwithstanding many essential differences in conditions. The use of multiple head group or radial drilling machines, with the spindles of the former and the saddles and columns of the latter so designed as to admit of any spacing between centers or of irregular spacing, is, however, one feature which has been carried even farther in plate shops than in machine shops, owing to the more varied need of drilling in even or staggered rows or peculiar formations.

For holding the work, in drilling along circular, elliptical or other arcs, there has also been developed the magnetic "old man," which is ordinarily a home-made device that shows considerable ingenuity and varies with the requirements of the shop. One of a portable type seen by the writer in a manufacturing plant where plate work is handled was the invention of the foreman in charge. This device is made of two channel bars held together with suitable braces and provided with three round iron legs. Inside of the channel bars, and mounted on wheels, is a carriage which permits of an easy movement of the drill back and forth. A pneumatic drilling machine is suspended on a spindle in the center of this carriage and is raised or lowered by a simple lever. The frame swivels freely around the upright from the magnets, thus allowing work to be done in a complete circle or, by adjusting the radius, in any curved or irregular formation. The holding power of the magnets can be regulated, up to the capacity given by their winding, to suit the work to be done; and there is practically no limit to the size of the work that can be handled with apparatus powerful enough. For countersinking and light drilling the lever feed answers the purpose, but by substituting a regular screw feed heavy drilling can be done.

Tools used in some shops include drilling and threading, and reducing machines especially for staybolts and similar work, together with the ordinary bolt threading, cutting and pointing machines used for odd lots not carried in stock. Furthermore, tools common to machine shops, such as slotting, shaping and even milling machines, are coming into more extended use, and a noteworthy tendency is the introduction of planing machines for truing the edges of heavy plates. Other machine work on frame supports, rods, heads, etc., is usually done in a regular shop for that purpose forming part of the same plant, failing which a small auxiliary machine and tool shop is maintained. Simple grinding, cutting-off and threading operations are taken care of as may be most convenient.

Riveting apparatus, from the small pneumatic hand tools to the huge hydraulic gap riveters, has been steadily improved in efficiency, enabling operations to be gradually speeded up, but there have been no recent developments of special interest. Among the larger machines an example of the best practice is a type of hydraulic

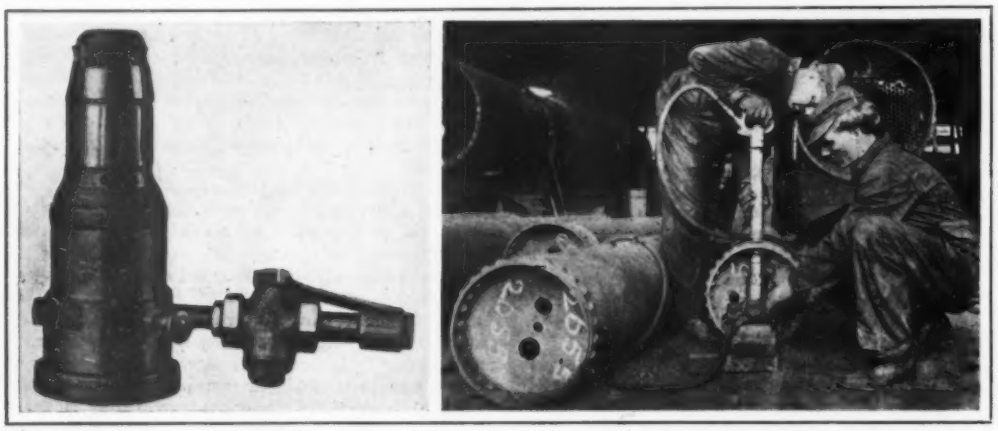


Fig. 2. Fig. 3.

Figs. 2 and 3.—A self-supporting holder-on and the way it is used in conjunction with a pneumatic hammer.

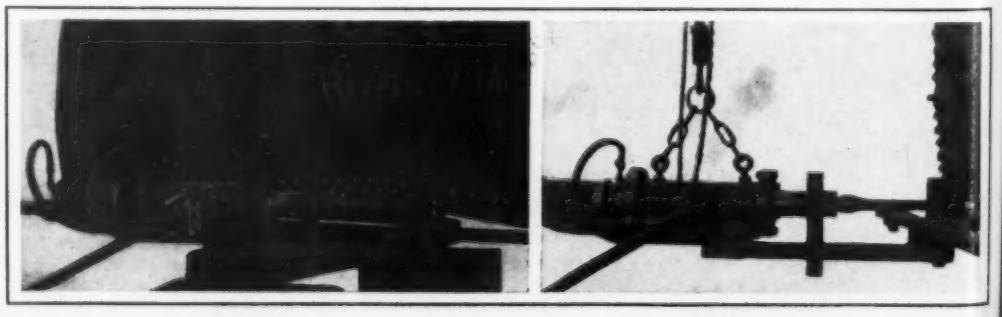


Fig. 4. Fig. 5.

Figs. 4 and 5.—A special tool in use for cutting off rivet heads and also for punching the rivets out.

*Reproduced from *The Iron Age*.

riveter, seen by the writer in several locomotive shops, which is designed to handle entire boilers, with firebox tops, tanks and tenders, complete. One of these has, for example, a depth of gap of 14½ feet and a width of gap of 54 inches. The maximum pressure capacity at 1,500 pounds exerted by the pump is 125 tons; but, by a special system which has been worked out for this class of riveting, multiple pressures of varying degrees, say 25, 50, 75, 100 or 125 tons, can be exerted, depending upon the size of the rivet and the work to be done. The head of the riveter is flush, which permits work to be swung in; and, as the bottom of the ram is also flush, there is no limit to the size of the boiler, tank or plates to be riveted. The width of the gap also enables fireboxes to be swung clear and, with the flush construction of the ram, to be riveted into place. A hydraulic crane for holding the work forms part of the equipment. This is of 20 tons capacity and also operates under 1,500-pound pump pressure. A separate operator for this is dispensed with by chains conveniently suspended for the movement of the bridge and trolley.

A feature of riveting work on the shop floor or about the yards is the increasing use of portable rivet heaters. Each of these is ordinarily self-contained, carrying a sufficient supply of oil for the day's work, and can be rolled about into any place where a small truck will go. The heating capacity of such a furnace is usually about 400 ¾ or ⅞-inch rivets per hour, and the apparatus can be operated on any of the various shop pressures on the compressed air lines. By reducing valves, however, the air pressure on the oil tank is always kept low, overcoming any danger of explosions. If the air hose is accidentally cut or punctured, as, for example, by being jammed against some sharp plate edge or corner in the shop, the oil immediately drains back to the tank, killing the fire and avoiding any accident.

In contrast to the steady but comparatively uneventful advance of riveting has been the more rapid gain of flanging and welding in boiler, tank and plate shop work—more rapid because of the ground that had to be made up. Flanging of heavy plates is a subject to which, except in a desultory fashion, very little attention has been paid in years past. Manufacturers have usually accepted it grudgingly as a necessity along certain lines, but to be avoided wherever possible. The expensive machinery needed for first-class results, including flanging presses, flange clamps and flange punches, has further militated against this work. Notwithstanding all obstacles, however, the use of both hot and cold flanging has, within the past two or three years, grown by leaps and bounds. This is due to the greater strength of construction required by higher pressures and temperatures; and, as in the case of steel castings, manufacturers are turning largely to outside custom plants having special facilities for flanging. The same is true, to a considerable extent, of dishing and other forms of regular and irregular hot pressing. As, however, each of these subjects calls for special, comprehensive treatment by itself, no attempt will be made here to do more than call attention to their importance.

In the case of difficult work, and where strength of construction is a material factor, welding has been resorted to as an aid to flanging. One job observed by the writer, which will serve as an illustration of this tendency, consisted of heavy water jacket plates for a smelting furnace, the flanges of which were very wide, with the corners turned nearly square. There was altogether too much stock at these corners to bend and press them into the necessary shape entire, and therefore autogenous welding was resorted to as an aid to the flanging operation, the stock at the corners being cut away and V-shaped pieces welded in. Another job consisted of a large sheet steel blast pipe, which required for its construction a number of angle irons of special shape. To make these angle irons two pieces of sheet steel wire were cut out and welded together at the corners. This method of making the angles proved to be not only better, but cheaper than the older system. For heavy, irregular shaping and flanging a practice borrowed from naval construction is the use of marine bending floors, which in a few large plants are effectively utilized.

In handling flues and tubing for boilers, condensers and other purposes, combination pneumatic machines for swaging, scarfing and welding have been introduced in many shops. With one of these a 2-inch flue, for instance, can be swaged and welded in about 5 seconds, making a smooth weld both inside and out and leaving the flue an even thickness. A rotary flue welder is also being successfully used.

Furnaces for annealing, flanging, hot-pressing and the heating of rivets, tubing and other stock continue to be mainly of the oil and gas-fired types; but the use of powdered fuel threatens to make heavy inroads on this practice. In the burning of oil an improvement brought about in many installations, as observed by the writer, is in having it take place entirely within the combustion chamber, outside of the heating area proper. Here, at the bottom, the oil is broken down to the hydrocarbon gases, which at the top of the chamber come in contact with the air necessary to complete combustion. This not only simplifies the process and makes it more efficient, but also increases the hourly capacity of the furnace, due to the fact that the thermal value of the fuel is immediately effective upon crossing the bridge wall into the heating area proper.

The blower systems installed with furnaces and elsewhere in shops show a marked advance in operating economy and efficiency over those of only a few years ago. Motor drive is now general, and some very ingenious systems of automatic electrical control, including manipulation from some central point, have been worked out. In contradistinction, also, to the former practice of setting up a blower anywhere, often back of a rubbish heap, the tendency now is to build an entirely separate compartment for it, with an ample intake supplied with pure air.

There are, in fact, improvements all along the line. The most gratifying feature of the year just closed, so far as boiler, tank and plate shops generally are concerned, is the fact that the apathy and indifference of former times seem to have been definitely shaken off. Real progress has been apparent lately, and much more will unquestionably be made in the near future.

Fig. 6. Fig. 7.

Figs. 6 and 7.—A device for holding on and driving up mud drum rivets and putting in the flue sheet rivets on a firebox.

Oil Fuel in Marine Boilers*

A PAPER read before the Institute of Marine Engineers by Mr. J. S. Gander dealt with the practical details of the installation and maintenance of systems of burning oil in marine boilers, and explained the precautions that must be taken if oil was to be burned successfully.

He said it was of vital importance to have clean bunker spaces. It was a common practice to clean those spaces with sawdust and bagging; workmen were apt to leave those materials in the bunkers, and especially the double bottoms, and when this happened heavier work was thrown on the filters and consequently on the staff. The operation of bunkering was a very simple matter, and the quantity of oil loaded could be readily ascertained by measurement with a tape line. Usually drawings were provided giving the bunker capacities per foot depth, but in any case it was easy to graduate a tank by running up ten tons at a time.

STEAM WITH OIL SYSTEM.

The methods used in the merchant service might be classified as the steam with oil, the direct pressure, and the compressed air. In the first system the regulation of the pressure of the steam supply to the burners was an important item. From practical experience he found the most economical pressure ranged from 25 lb to 35 lb. per sq. in. The consumption of water for burner steam was not greater—in his opinion, it was less—than when the steam supply was at 60 lb., and several advantages accrued from the lower pressure.

The adjustment of the steam and oil valves needed very little practice, but if it was incorrect heavy smoke might be caused at the funnel and carbon deposit on the striking pillar. A thin smoke was rather desirable as an indication that steam was not being wasted up the funnel. Smoke could be immediately stopped by giving additional steam or decreasing the oil supply. The appearance of the flame in the furnaces, its color and form, gave indications of economical combustion or otherwise. With perfect combustion the flame began two or three inches from the nozzle, the intermediate space being filled by a greyish vapor, and wrapped round the striking pillar in a blaze of brilliant white slightly tinged with yellow. Too brilliant and too white a flame meant that too much steam was being used. With too much oil the flame assumed a deeper yellow tinge, and streaks of dark would be observed in the stream from the nozzle. Excess of oil would cause smoke in the furnace, and if still more oil were supplied to the burner the mixture did not atomize and was deposited in a liquid state on the striking block.

So far as marine boilers were concerned the principal drawback of the steam system was the water consumption. In the case of the Murex this amounted to 10 tons a day, or allowing 2½ tons for engine and auxiliary losses, to 7½ tons for burner steam. Assuming an average consumption of 14½ lb. of water per lb. of fuel and a consumption in main boilers of 17 tons a day, the percentage worked out at three. In actual practice, when making up the loss from an evaporator the condensing and blowdown losses considered with the efficiency of the evaporator raised the ratio to 5 per cent. Thus on a daily consumption of 17 tons 0.85 ton of fuel was used for the burner steam supply.

The steam with oil system had the merit of simplicity, and where a cheap supply of fresh water was available, as in riverboats, and for shore installations, would probably hold its own for some time yet on account of cheapness of first cost. In ocean-going steamers the direct pressure system was far more economical, the additional first cost being repaid in a few months by the 5 to 8 per cent saving of fuel that might be expected.

DIRECT PRESSURE SYSTEM.

In the direct pressure system the oil was injected into the furnace by pressure from a fuel pump through a burner pierced at the end by a very minute hole, the fuel being heated and filtered before it reached the burner. The temperature at which the oil would give the most economical results depended on its nature and gravity. An average mixture of fuel oil would require to be heated to about 160 deg. Fahr., Tarakan crude to about 120 deg. Fahr., and some of the heavier European residues to 240 deg. Fahr. If the oil were too cold the spray would enter the furnace without igniting; if it were too hot it would ignite as it left the orifice. With the correct temperature the flame should appear at little more than an inch from the burner. The best results were obtained with a pressure of from 30 lb. to 40 lb. The color of the flame gave the same indications as with the steam and oil system.

ADVANTAGES OF OIL FUEL.

From the standpoint of the marine engineer, oil fuel offered the following advantages: The quantity of bunkers received could be quickly ascertained with accuracy, no tallying was required, and no trimming; no cleaning of fires being necessary no currents of cold air which might cause damage could enter the furnace; full and regular steam could be maintained in all climates without trouble; the steam was under perfect control, and on receiving an order by telegraph the engineer could increase or decrease the steam supply to the fuel pump without leaving the engine room; the combustion was more complete than with coal, and therefore the calorific efficiency was greater; the engineer, if necessary, was independent of his firemen; the boiler tops, bilges, and engine room and stokehold spaces could be kept absolutely clean, and there were no smoke or fumes to discolor paintwork, or ashes to choke bilges; combustion was not affected by heavy weather—at times when coal-firing might become impossible the oil-burning vessel could carry on as under normal conditions, and the bilges were always clear in the event of a washout; with intelligent working, oil fuel was practically smokeless.

Far less boiler trouble might be expected with oil than with coal. Perhaps the most frequent source of leaky tubes in boilers was the constant necessity for cleaning fires when coal was burnt, currents of cool air then passing to the backends. With oil the only cleaning necessary was the occasional removal of small quantities of carbon. The furnaces were more evenly strained, especially with the systems where the whole of the furnace acted as a heating surface, and it was reasonable to suppose that the circulation was more efficient for the same reason.

* Reproduced from the London *Times*.

Illumination from Large Area Light Sources—I*

Some Experiments Carried Out With Actual Home Conditions

By Herbert E. Ives

ADVANTAGES AND DISADVANTAGES OF HOME EXPERIMENT.

A GREAT advantage of using one's own house as an illumination laboratory is that one can live with the lighting system and learn how it wears, as the various normal activities are carried on at their normal times. The home rooms have their furniture in place, which is a tremendous advantage. Everyone who has moved to a new house knows how very different a room appears before and after furnishing. It is the difference between discomfort and comfort, and to attempt to judge a lighting scheme in a bare laboratory room means too serious a handicap. Often a mere touch of decorative treatment will reclaim a lighting device which, in its crude form, is hard to imagine desirable.

The disadvantages are several. A considerable one is that it is difficult and often impossible to make changes in the positions of the outlets. A certain amount of flexibility is achieved by using base-board connections, but after a more or less unsightly structure of wires or tubes has arisen, the time is likely to come when something logically next on the programme cannot be tried out without rebuilding the house. This limits experimentation, consequently some of the things described in this paper are incomplete, and the descriptions must end with suggestions as to what might be better. The usual separation from proper tools and the time taken to make what should be trivial changes constitute other disadvantages. A special house with furniture complete would possibly be the right thing for a study of this kind, but even this would labor under the disadvantage that one would be likely not to feel "at home," and would not be apt to live in it long enough to determine how it wore.

A CHARACTERISTIC OF HOME LIGHTING.

A characteristic of home lighting which makes it well worth studying by a lighting company is that efficiency counts for little. In domestic lighting the real problem is to obtain a pleasant illumination effect, almost without regard to cost. In the experiments here described no attention whatever has been paid to efficiency. The author has put himself in the position of a householder who demands certain lighting effects and is willing to pay for satisfaction. In fact, I believe that many possible lighting schemes have not been tried at all—notably copies of daylight distribution—because the illuminating engineer has been apt to think too quickly of efficiency. He has been an engineer before being an artist, whereas the more fruitful procedure is to first obtain the desired effect and then count the cost.

Meanwhile it remains a sad fact that we have generally available no method of measuring lighting conditions which will do more than distinguish between two so extreme in quality that a mere casual glance will tell which is good and which is bad. Until we are better off in this respect the trained eye must be encouraged as the best we have.

REMARKS ON DIRECTION, DIFFUSION, GLARE AND CONTRAST.

One peculiarity of daylight illumination from windows is its direction. Most artificial systems cast the light downward from a point near the center of the ceiling. There then occurs in changing from day to artificial light a 90 degree rotation of shadows. By day they are long and sweep across the room; by night they are short or completely covered by the shadow-casting object. A clear illustration of this change is to be seen in the ordinary railway car. By day the illumination comes from the windows at the two sides; at night from the high centrally placed units. As far as direction is concerned, side wall brackets, floor standards or table lamps on side tables approximate more nearly to window conditions.

Diffusion of light with soft shadows, as is well known, is most perfectly brought about by the use of a large area of light source and is one of the chief merits of the "indirect" system. A certain degree of diffusion may also be obtained by a multiplicity of light sources, although this is apt to give merely a multiplicity of sharply defined shadows instead of the soft shadows of the large source. The ordinary window with its area of 5 or 6 square feet (0.46 or 0.56 square meter), gives a far better degree of diffusion than most artificial schemes. Another factor in diffusion is the color of the light. Blue light diffuses better than yellow. It is therefore quite possible that daylight is inherently apt to be better diffused than is yellow artificial light.

In regard to contrast and glare, it is well to bear in mind some numerical data. A Welsbach mantle has an intrinsic brilliancy of 35 candle-power per square inch (6.45 square centimeters); a tungsten filament about 1,000 and a patch of sky about 2 to 3. For the same intensity of illumination, that is, the same general brightness of illuminated objects, therefore, the physical contrast between the brightness of the illuminated objects and the light sources themselves will be from ten times to hundreds of times greater with visible "direct" artificial light than with daylight. If the light sources are concealed, this contrast may be avoided, but it occurs again to a disturbing degree if specularly reflecting surfaces are present. These reflect images of the light sources with about 1/10 or 1/20 of the intrinsic

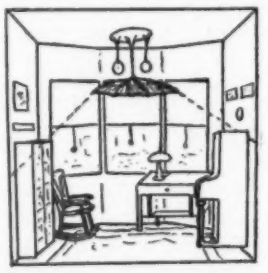


Fig. 1.—Diffused illumination from side walls.

brightness of the parent source. It is, in fact, immediately evident to an expert whether the lighting of a room is due to small or large sources by an inspection of these two things—the sharpness of the shadows and the brightness of the specular reflections. Half of this handicap of small sources is eliminated by entirely avoiding specularly reflecting surfaces.

SOME CHARACTERISTICS OF DAYLIGHT OUT-OF-DOORS.

Out-of-doors daylight may be pleasant or unpleasant. In a previous paper[1] which records brightness measurements of typical outside illuminations, certain conditions were found to be most pleasing. These were an excess of brightness in the upper hemisphere, usually with a maximum near the horizon, and (a very essential condition) sunlight directed from the side to give long shadows.

A criticism which has been made of many "indirect" installations is that the bright "sky" furnished by the light ceiling is bounded by dark walls carried up above the eye line. This gives an effect of being down in a well, or as though the room had been lifted up away from one. To produce a real out-of-doors daylight distribution, the above quoted work would call for an extension of this brightness down to the horizontal. This would tend to overcome an objection frequently

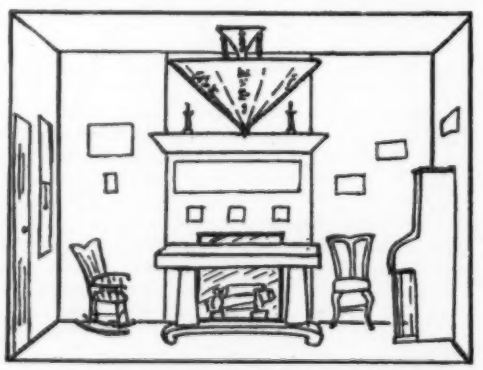


Fig. 2.—Illumination from large area, low brightness overhead source.

made to the "indirect" system—that faces are subject to unnatural downward shadows. Out-of-doors our faces receive considerable horizontal illumination. In addition, the habit of wearing hats must be taken into account. Hats protect the eyes from overhead bright areas and also reduce the vertical component of the illumination on the face.

The effect of the large sky angle on the extreme brightness ratio must not be overlooked. Out-of-doors the sky approximates to an infinite plane. Under this a white surface will be as bright as the illuminant, while other objects will be bright in proportion to their reflecting powers. As the area of "sky" is decreased, its brightness remains the same, but that of illuminated objects becomes less, thereby increasing the extreme brightness ratio between unconcealed illuminant and illuminated objects. Diffusion is also decreased and shadows take on a more definite downward direction.

AN ATTEMPT TO COPY OUT-OF-DOORS DIFFUSED DAYLIGHT.

The guiding idea here was to carry the direct illumination of an "indirect" system down on to the walls in such manner as to approximate the out-of-doors conditions, and thereby produce a pleasant diffused illumination. The room available was a small one, about 14 feet (4.27 meters) square, furnished with a central fixture and papered a medium light buff. Under this central fixture was suspended a yellowish Japanese umbrella of oiled paper, convex side up. The direct light of the lamps thus fell on the walls, which acted as the chief light source of the room, since the transmission of the umbrella as used was low, while the ceiling was little brighter than the walls and largely invisible because of the comparatively small size of the room. (See Fig. 1.)

A peculiar merit of this scheme lay in the splendid illumination of the pictures on the walls. These had to be slightly tilted to prevent reflection of the bright light sources, and in the direction of the entrance doorway a translucent Japanese fan was placed above the umbrella to conceal the lights. This installation was used for many months and gave great satisfaction. The "well" appearance sometimes noted in indirect systems was entirely absent. There was no tendency for the eye to wander upward to a bright point above. Although the illumination seemed low, it proved ample for sewing and other close work, which was done without the fatigue customary to working with "artificial" light. A pleasing addition to the general diffused lighting was furnished by placing a table lamp on one side, whereby the direct light of the sun was copied. One point proved to my satisfaction by this experiment is that light walls, well illuminated, are not productive of evil. On the contrary, they help in a marked degree the general effect of brightness. A room looks brighter with bright walls and, unless some extreme case is taken, this means that the object—to light the room—has been attained.

This lighting arrangement was only given up when I moved away from Cleveland. It needs a small room, or, in a large room, a number of ceiling outlets not far from the walls in place of one central one. It is intended at some future time to place outlets in a large room which will make possible lighting the walls in a similar manner and the expectation is that it will furnish a very satisfactory illumination. In some indirect or semi-direct installations it might be of interest to tilt the units near the walls in order to secure a similar effect. These units might be made purposely unsymmetrical.

A LARGE OVERHEAD LIGHT SOURCE.

The characteristics of "indirect" lighting would be obtained without the process of reflection if a large enough low-brilliancy source was used. This was experimentally accomplished in a very simple manner by the use of a yellowish oiled paper Japanese umbrella of 4 feet diameter, turned point down, within which are the lights in frosted globes. (See Fig. 2.) A certain amount of light falls on the ceiling, so that it might be called a "semi-indirect" system, but by far the greater part of the illumination is due to the visible light source. This is of rather low intrinsic brilliancy, so that it can be looked at without any sensation of strain, and gives ample light all over the 16 foot by 20 foot room with an emission of about 7,500 lumens.

Now as to its merits and defects. Because of the size and low intrinsic brilliancy shadows are soft and specular reflections are too dull to be annoying. Because of the conical shape a better illumination of the walls and far corners is obtained than would be possible by a ceiling reflection scheme. On the other hand, the direction of the shadows is, for the center of the room at least, straight down and, therefore, different from the most agreeable daylight condition. But the greatest defect lies in the fact that the principal light source is visible, and, low as is the intrinsic brightness, it is the brightest object visible and is too bright to be continuously in the field of vision. When the occupants of the room sit around the center table or sit sideways to the light, the illumination is extremely satisfactory. If, however, when a number of people are conversing, they face each other across the center, then in time the large bright umbrella becomes an irritant—far less, of course, than would the usual bright points, but still noticeable to a sensitive and critical eye.

* A paper presented at a meeting of the Philadelphia section of the Illuminating Engineering Society, May 16th, 1913, and published in the *Transactions of the Society*.

[1] "The Distribution of Luminosity in Nature," SCIENTIFIC AMERICAN SUPPLEMENT, September 27th, 1913, p. 204.

An experiment was tried with a still larger light source, but it had the same defects. The conclusion was arrived at that by no process of increasing the size of the source, unless it actually occupied the whole upper hemisphere—which is out-of-doors daylight on a sunless day—could the light source be made innocuous. Diffusion is not alone sufficient. Any system by which the light source is the brightest visible thing gives an extreme brightness ratio which is too great to wear well. If, in the room illuminated with the large umbrella, the hand is held over the eyes, or an eye shade is worn, it leaves little to be desired; there remains merely the question of the direction of the light to be objected to; indeed, many might prefer the centrally located source. Of course, the higher the light source the less this defect would be, so that the "indirect" practice of making the ceiling the real source chooses the best condition, for it then approximates, in a small room, to a concealed source.

What seems to be most desirable in this particular room is some means of illumination with this large low brightness source, at the same time keeping it concealed. That done, the range of visible brightness is not too great. As will be seen below, daylight illumination by windows does something of this sort.

CHARACTERISTICS OF PLEASANT DAYLIGHT ILLUMINATION FROM WINDOWS.

I have no brief for daylight illumination in general, nor for all kinds of window lighting. Excessively unpleasant illumination may be found by day. My observation, common to that of others, is that window lighting is not always satisfactory. It may be insufficient, or it may cause excessive contrast in brightness. In my own house the first floor living room has one door and one window on the front and two windows at the side facing another house. Ordinarily the room is not sufficiently lighted by daylight. The front window is too narrow. If the shade is run up to the top it is impossible to look with comfort at the window, because the large patch of bright sky then visible is in violent contrast to the unilluminated wall at the sides of the window. Even with the shades down, so that the sky is not seen, the houses opposite are apt to present too great contrast of brightness to the walls adjacent to the window. Only under one condition is the daylight really satisfactory, and that is when a spot of sunlight falls well back on the floor, the houses opposite being in the shade. Then the walls adjacent to the window receive light from the floor, the ceiling receives light from the floor and from the pavement outside and all is bright and cheerful. With snow on the ground outside, the effect is still better.

Another case of bad daylight illumination is furnished in the upper floors of a tall office building which is not faced by any other structure. If one sits facing a window, one sees a large expanse of bright sky, which soon becomes painful. In these rooms the official habitually places his desk so that his back is toward the windows. Visitors who face the windows do not find daylight pleasant.

Most fortunately a case of the other kind is to be found in my own house, namely, an instance of a pleasant and satisfactory daylight illumination. This is in a second floor room, facing south, illuminated by two adjacent windows in a bay nearly the width of the room. The wall paper is a figured gray of approximately 45 per cent reflection coefficient. The dimensions of the room are shown in Fig. 3. A large room of this type is perhaps one of the hardest to illuminate satisfactorily by daylight or artificial daylight because of its depth. One with windows on two sides would have been preferable and easier to deal with, if it had been available.

Observations, both qualitative and quantitative, made from time to time in this room, revealed some interesting points. (1) At all times, raising the shades above the middle sashes made the lighting less pleasant. (2) The room was brightest and, on the whole, most pleasing when the sun streamed in on the floor or wall and shone on the street below. (3) The effect was unpleasant when the sun fell upon the (gray stone) house fronts opposite. (4) A gray or misty day was not pleasant. (5) The distribution of illumination or brightness was such that the face of a person sitting with his back or side to the window received sufficient light from the room so as not to be in marked contrast to the background, or to have the two sides of his face unduly different in brightness.

Two sets of measurements of brightness are plotted in Fig. 3, one for the case of sunlight streaming in the window, the other when it is on the street below, but not streaming in nor on the houses opposite. Both effects were extremely satisfactory.

An analysis of the various data has led me to the following conclusions:

The most pleasant conditions are those when the effective light source is of three parts: (1) A large area of bright sky subtending the solid angle of the window, invisible from the greater part of the room and illuminating the floor and lower part of the room. (2) A large area of intrinsic brilliancy about one tenth that of the sky, visible from the room (houses opposite). (3) A large area of intrinsic brilliancy about one fourth to one fifth that of the sky, invisible from the greater part of the room, but illuminating its ceiling.

Add that these light sources are at the side, and remember that the bright sky is of much lower intrinsic brilliancy than most artificial light sources, and the complete specification of pleasant window daylight of this room becomes something like this: *illumination from large area concealed light sources at the side*, that is, just the case which is absent from prevalent lighting systems.

There must be added to this set of conditions the further one that the walls adjacent to the window must be well lighted in order to prevent excessive contrast. This is frequently accomplished by having windows on two sides. In the present case the walls adjacent to the windows are perpendicular to these and are, therefore, lighted by one set of windows.

Probably to an architect, who has made a study of window lighting, this is an old story. It is interesting in the light of these observations to notice that low broad windows (frequently in alcoves) are becoming

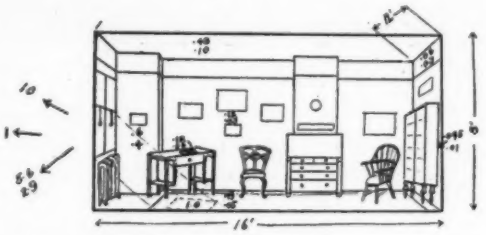


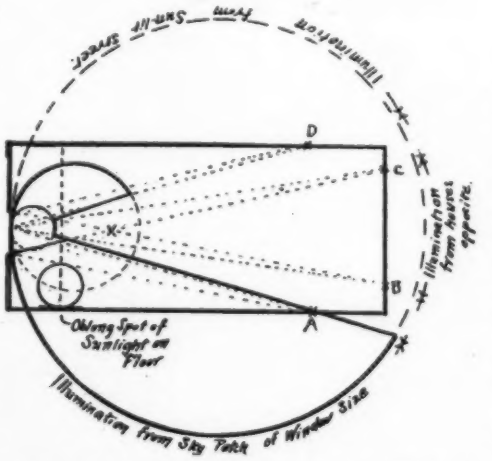
Fig. 3.—Distribution of surface brightness in arbitrary units by daylight. Large values, a case where sunlight falls on floor. Small values, sun not streaming in.

common in the newer houses, taking the place of the old-fashioned high narrow window, the upper portion of which sometimes cannot be used without exposing to view a dazzling patch of sky.

THE WINDOW AS A LIGHT SOURCE.

The numerical data given in Fig. 3 made possible a study of the windows of this particular room as a light source.

As viewed from a point in the room the windows present practically the appearance of two adjacent squares 30 inches by 30 inches (0.762 meter by 0.762 meter), with their centers at a height of 42 inches (1.07 meters) above the floor. As viewed from various points the angle subtended by the light source, of course, changes, diminishing to zero above and below and to either side. Were the landscape as seen through the window of uniform intrinsic brilliancy, then the window would be equivalent to a flat uniformly bright plate. It could be copied by a sheet of thick opal glass illuminated from outside, or by a diffusely reflecting surface, such as an "indirect" ceiling source turned through 90



The window considered as a point source of light.

degrees. This, however, is not the case, except when in a high building facing the sky, or if a fog reduces all out-of-doors to a nearly uniform gray (a ratio of sky to houses of 2 to 1 was found by measurement on a foggy day). Both of these conditions are found to be undesirable, as noted above.

In the second-story room, which was studied chiefly, the change of intrinsic brilliancy and effective area may be followed best by consulting the drawing, Fig. 4, in which the window is considered, for convenience only, as a point source of light. Starting directly below the window the illumination is from a narrow slit of the intrinsic brilliancy of the sky. As the test surface is moved away from the window this slit increases in width (as the cosine of the angle with the normal) until a point (*A*) well back on the floor is reached. Here the tops of the houses opposite become visible, cutting off part of the sky. At the point (*B*) the sky is no longer visible and from there to the point (*C*) high up on the wall the intrinsic brilliancy of the window is that of the house opposite. Between (*C*) and (*D*) the street below becomes visible and from (*D*) over the ceiling to the window the illumination is from a patch of the brightness of the street surface. There are, therefore, to be distinguished (in this case) three different brightnesses, the distribution of illumination from each of which is represented by a circle of appropriate diameter, tangent to the window. From the brightness measurement of Fig. 3, it appears that these three circles should have diameters for the most pleasant condition of about 10-1-3, and they are so represented in the figures.

It will be seen that a seated person in almost any part of the room, looking toward the window, sees only the comparatively dull houses opposite. The floor and ceiling are illuminated by a much brighter source than the houses and act as secondary light sources of low brightness. If the sun strikes the floor the spot becomes another secondary light source. The most startling thing is the very irregular shape of the light distribution curve and its sharp transition from maximum to minimum, unequaled, I believe, in any commercial lighting unit. Were it not for the fact that the source (window) is large these sharp transitions would cause sharp contrasts of light and shadow between the portion of wall and ceiling represented at *A*, *B*, *C*, etc. Actually, the deviation of the window from a point source makes the transitions gradual and soft.

An interesting feature of the distribution from a window is that it tends to diminish the extreme brightness ratio. The greatest illumination is on the floor and furniture, which are almost invariably the darkest surfaces. With a uniform distribution from a side window or with many artificial systems the floor and furniture retain the normal brightnesses which their low reflecting powers give them. With windows they are made several fold brighter, which must be no inconsiderable factor in the general effect. This fact explains in part why with "indirect" systems the floor and furniture are apt to appear unnaturally dark. In order to preserve the daylight ratio of brightness above and below it would be necessary with the "indirect" system, with its bright ceiling, to exchange the floor coverings and furniture for some with at least a four or five fold higher coefficient of reflection. The excellent appearance of white tiled barber shops under the "indirect" system is confirmatory of this.

(To be continued.)

Fixing a Frontier

COMMANDER HERBERT A. EDWARDS, the officer who was lent by the British government for a period of three years, to command the Bolivian Survey Commission, has just completed over 200 miles of frontier survey. Commander Edwards and his party, whose duty was to survey mostly unknown country, the disputed frontier between Bolivia and Brazil, had traveled up the Abuna River to a settlement called Santa Rosa, whence they cut across country to meet another section of the Commission. Both parties then returned down the Abuna on the completion of the survey.

The great achievement of the expedition is that they fixed all their longitudes by time-signals sent by wireless telegraphy from Porto Vallo, situated 120 miles from the base of operations. A party was left at Porto Vallo, and, by the courtesy of the Brazilian government, time-signals were sent every night. Commander Edwards carried with him a rough receiving set and a long wire, which was rigged up on trees. He has proved that wireless telegraphy will enable the explorer to dispense with chronometers, and easily and accurately fix all longitudes. Commander Edwards says this will begin a new era in exploratory surveying. He eulogizes the work of a wireless expert, Mr. Chapman, who labored night and day to make the experiment successful. In the course of his work this gentleman had terrible experiences with hornets, ants and other pests. He was provided with climbing-irons on his legs, in order to ascend the highest trees.

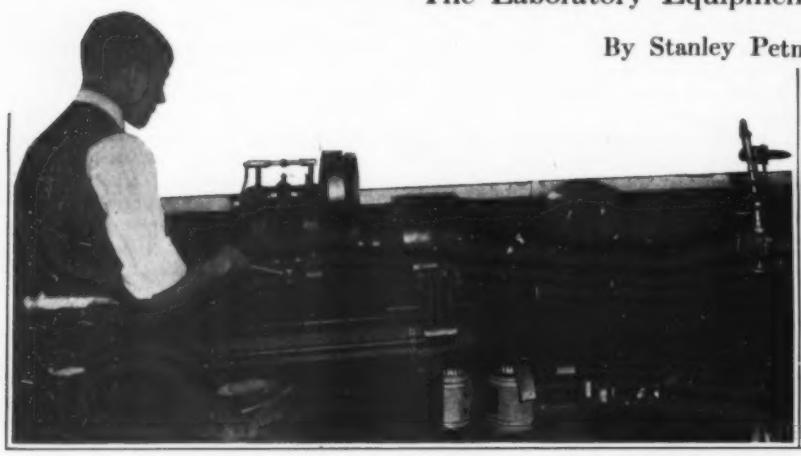
The commissioners have still to erect boundary marks along a portion of the frontier, but the commencement of the rains will render it impossible to deal this year with a section of forty miles of frontier which, it was hoped, would be covered during the present season.

Size of Families in France.—The latest statistics on this perennial topic are as follows: Of the 11,317,424 families in France, 45 have 18 or more children, and 37 have 17 children each. On the other hand, 2,661,978 families (23.5 per cent) have only 2 children, while 1,805,744 (15.9 per cent) have no children.

How Automobile Materials Are Tested

The Laboratory Equipment of Great Factories

By Stanley Petman, M.E.



An impact machine for determining the fatigue point of metals.

A camera which makes micro-photographs.

No automobile manufacturer of repute sells a car every part of which has not been scientifically tested. Wonderful testing laboratories now constitute an essential part of every well-equipped automobile factory. The result is that year after year the automobile ascends by another rung in the ladder of efficiency. The object of all this laboratory work, stated in the fewest possible number of words, is to discover why something that works out beautifully in theory so often fails in practice. In this article the more important methods of laboratory testing are disclosed and the machinery used illustrated.—EDITOR.

ALTHOUGH there is little doubt that racing has had a beneficial influence on the automobile industry in that it has made plain certain weaknesses in the construction of cars and pointed out the way to their elimination, there is nothing that has had, and still has, a more direct influence on the perfecting of parts than the immense amount of laboratory work that is done. There are few who own or drive cars who realize the scope of such work or who know that nearly every automobile factory of any size maintains a well-equipped chemical and physical laboratory where every day hundreds of dollars worth of valuable parts are deliberately smashed, or dissolved or burned up just to find out exactly what they are composed of and how much strain they will stand.

This laboratory side of the automobile industry is an interesting side for its shows to what lengths an automobile manufacturer will go to determine within the finest possible limits the structure and characteristics of the materials he uses. Nor is such work confined to automobile factories alone; part makers as well, of which there is a legion, maintain their own laboratories in a great many cases. Though the source of their metal supplies may be relied upon, they prefer to take no chances, and ever and anon the testing and trying goes on—to the ultimate benefit of the automobile user, of course.

Testing Steel for the Automobile.

Just as surely as steels enter largely into the construction of the automobile just so surely has their perfection been responsible for raising the modern car to its present plane of perfection. There are hundreds of different kinds of steel each suited only for a particular kind of work and each varying possibly by only a fraction more or less of a certain element in its composition. Thus, for instance, the greater the carbon content in steel, within certain limits, the harder can it be tempered.

Suppose for example that a steel is to be developed, which, theoretically, should temper to a certain hardness and at the same time show other properties such as elasticity and toughness. Experience indicates that certain elements should be added to the raw material in order to obtain these properties, and the steel is made accordingly. Then it is tested for hardness with an instrument styled a scleroscope; an instrument that consists, briefly, of a graduated glass tube, like a thermometer, containing a small pointed piece of steel of known weight. The specimen to be tested is clamped in place beneath the weight which is permitted to drop on it. The height to which it rebounds, ascertained by means of the graduations, serves as an indication of its comparative hardness. If the specimen comes up to expectations, it is put to other tests to determine its other properties. But if it does not, it is analyzed to find out just what is the matter with it and how it may be improved so that it will render better service.

A machine for testing the hardness of metals.

An apparatus for electrically analyzing copper alloys.

As the amount of carbon content bears direct influence on the degree of hardness that can be obtained, one of the first steps is to determine accurately the percentage of carbon it contains. Probably the quickest and surest way of obtaining the information is to burn the steel and measure the carbon that is set free. This is done by placing a known weight of steel filings in an electric furnace, raising the temperature to about 950 deg. Cent. and passing purified oxygen through it. The oxygen combines with the carbon to form C O_2, which passes out and is absorbed in weighed bulbs of caustic potash. By simple computation, in which the increase in weight of the caustic potash bulbs is multiplied by the constant .273 and divided by the weight of metal placed in the furnace, the percentage of carbon is ascertained directly.

Even where steel alloys have been developed and selected for certain uses and are giving continuously good service, the testing is still carried on to make certain that subsequent alloys are equal to the original. Samples from every batch are analyzed and tried, and in this way the manufacturer of the car knows that the material in John Smith's car is as nearly like the tried and tested material in his own experimental vehicle as human ingenuity can make it. It is insurance for the car owner.

In the development of nearly all steel alloys used in automobile construction, heat treatment, which a few years ago was virtually unknown, plays a very important part. The steel for each particular purpose—for axles, for gears and for springs—must be tempered just so and just as a batch of bread may be ruined in the baking, either over-done or not done enough, so may a batch of steel be ruined in the tempering process.

How Defects in Broken Axles Are Studied.

Suppose, for instance, that a number of broken axles have been reported to the factory. A part of one of the axles is sent to the laboratory, polished and placed under the eye-piece of an instrument styled a micro-metallagraph. A powerful arc light is focused on it. If the steel, for example, is 0.9 carbon and has been properly heat treated its surface will appear pebbled all over and the color will be uniformally gray. If, on the other hand, it has not been properly heat treated, the surface probably will appear mottled showing the presence of cementite. If it has not been hardened at all, which is unlikely, but is in the normal condition, the surface will show a dark etching constituent which microscopically is termed pearlite. In any case, the chemist can tell at a glance whether or not a specimen has been properly heat treated.

Physical testing, of course, is no less important than chemical analysis, for by its aid the connecting link between theory and practice is made apparent. The steel, which is used in ball bearing races, for instance, must be capable of being tempered very hard; it must be tough and fairly elastic; and above all it must be wear resisting to the greatest possible degree. All of which is known and a suitable steel for the purpose can be laid down in theory. After the steel is made

Ball-bearing load-testing machine.

the ball bearings are placed in special apparatus and run under service loads for what is the equivalent of years and years in a car. If they "stand up," well and good; but if they do not, they are analyzed and tested, and it is discovered wherein they are wrong, thus reconciling theory and practice.

Powerful Testing Machines for Abusing Steel.

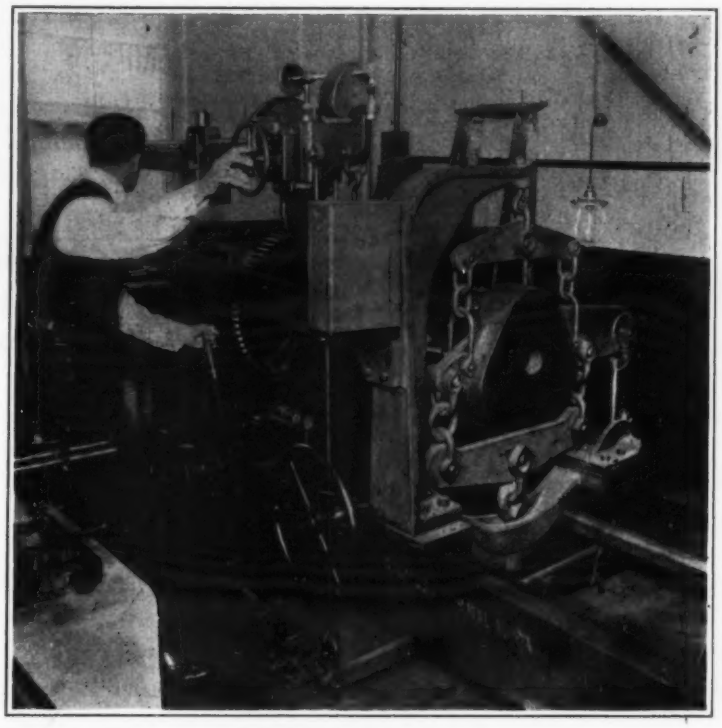
For the testing of steels in which great tensile strength or a comparatively high degree of elasticity or toughness is desired, a number of pieces of special apparatus has been developed. In them, the steel is bent and twisted and squeezed and stretched and otherwise abused until its characteristics have been ascertained and recorded for future reference. Among these pieces of apparatus, the torsion testing machine is a marvel of strength and accuracy though its operation is quite simple. If a crankshaft is placed between its untiring jaws and the power applied, slowly but surely it will be twisted almost out of all semblance to its original shape, just as if it were so much cheese or putty. The dials reveal the fact that no less than 85,000 pounds pressure has been required to deform it permanently. Needless to add, no crankshaft in an automobile engine ever is subjected to a twisting strain of 85,000 pounds in normal service. The purpose of the machine is to determine just how much twisting a crankshaft, or any other part, will stand before it takes what is known in engineer's parlance as a "permanent set"; in other words, it is to determine the elastic limit of the metal.

The tensile testing machine accomplishes a somewhat similar purpose. It is another piece of apparatus that is designed for a sort of destructive criticism that in the end is constructive; it pulls things apart, and in doing so gives valuable information. Its massive jaws grip the two ends of a prepared specimen of metal, and at the touch of a lever the metal is stretched out to the breaking point, which is exactly what the operator wants to discover. When the arm of the machine balances, he knows that just a very little more stretching will rupture the specimen and that a specimen showing a tensile strength of 119,000 pounds to the square inch, an elongation of 18.5 per cent and a reduction of area of 59 per cent is a suitable steel for front axles, for example. If a specimen of steel on test will not show these characteristics it is not suitable for that particular work, and it is discarded in favor of something else. Always, new materials are tested in this way before they are put to work.

As an interesting case in point, to show the object of physical testing and the benefits which accrue from it to the owner of a car, the steering knuckles and the impact machine are particularly apropos. Other than the braking mechanism of a car, there is nothing that is of greater importance than the steering apparatus. To be absolutely dependable it requires to be made of materials which have characteristics peculiar to themselves. The steering knuckles must be capable of sustaining tremendous strains, and at the same time they must not give way under continuous vibration, which operates to crystallize the metal and cause fractures.

With the impact machine the laboratorian can determine exactly how much vibration a given specimen can be expected to withstand in service. A standard size sample is placed in the machine and repeatedly struck blows of a known strength until the metal literally is tired out and fails. The number of blows required to break the specimen serves as an infallible indication of its resistance to fatigue. For the examination of copper alloys, of which there are upward of 25, the electrical method is perhaps the simplest and the most accurate. Bearing bronze, for instance, is dissolved and placed in a platinum dish, the whole is placed in a piece of special electrical apparatus, and immediately the current is turned on, the copper commences to deposit on the dish. After the action ceases the dish is weighed, the increase in weight representing pure copper. The percentage of copper in the alloy determines its suitability for a special purpose.

All such testing and trying is of special interest to the automobile owner. The policy which a few years ago dictated that a certain number of cars be built and put on the road in the hands of owners that their faults might develop for correction in the next batch of cars, now is obsolete. It was not very long before automobile manufacturers came to realize that such a policy was not only false economy, but ruined their reputations as well. And the net result of the realization is reflected in the splendidly equipped and carefully maintained testing laboratories connected with most automobile factories, where present excellence of products is calculated to serve as a basis for future reputation.



The torsion testing machine.

The tensile testing machine.

Explorations in French Guiana.—Under the auspices of the Society of Geography, of Paris, a well-equipped expedition, led by M. Jean Pilinski de Belty, is exploring the unknown mountainous region near the southern border of French Guiana, about the headwaters of the Araoura and Camopi rivers.

Water Clouds at Low Temperatures

Consider a fog in winter, with a temperature far below freezing. Ice fogs are not unknown, but the ordinary winter fog, however low the temperature, consists of water drops. The water is supercooled. When brought into contact with a solid object, water in this metastable condition immediately freezes. Hence the heavy deposits of "rime" that a cold fog leaves upon the branches of trees, telegraph wires, and the like. What is true of fog is, of course, true of clouds; the heavy strato-cumulus, the typical cloud of winter skies, consists of water, not ice. Even in the polar regions water clouds are probably commoner than ice clouds.

To what degree a droplet of water suspended in the atmosphere may be cooled without changing to ice is unknown. An observation that bears upon this question was made by Dr. George C. Simpson, a member of Capt. Scott's antarctic expedition, and was reported by him in a recent address before the Royal Meteorological Society in London. While surveying the western coast of McMurdo Sound he observed a fine fog-bow opposite the sun, with a radius of 38 degrees. The colors of this bow, and the presence of a faint supernumerary bow within it, proved it to be a rainbow (i. e., due to water drops), and not a halo (due to ice crystals). The temperature of the air at the time was 21 degrees below zero Fahrenheit, i. e., 53 degrees below the freezing-point! A further proof that the fog consisted of water was that the hair of sweaters and fur bags became covered with rime. Ice needles in the air could not have formed such a deposit.

From this observation Dr. Simpson draws some interesting conclusions concerning certain familiar optical phenomena of the atmosphere. One of the commonest of "photometeors" is the corona—the ring of prismatic colors, usually smaller than a halo, seen around the sun or moon when shining through thin clouds. The corona is an effect of diffraction, and it has been universally supposed that the diffracting bodies may be water drops, dust, or ice crystals. According to Pernter's great treatise on atmospheric optics, the best-developed and most beautiful coronæ occur in ice clouds. Pernter appears to have been misled by the assumption that the high clouds in which the finest coronæ are seen must consist of ice on account of their low temperature, but Simpson has shown that this is not the case. In fact, Simpson's observations throw doubts upon one of the fundamental assumptions of meteorology; viz., that cirrus and cirro-stratus clouds are always ice clouds. The optical theory of the supposedly ice-formed corona, as developed by Pernter, contains some striking fallacies, and that these were not pointed out before the year 1912 is a very good illustration of the fact that meteorological optics is a sadly neglected subject. Simpson appears to have shown conclusively that the corona is *never* produced by an ice cloud. That the higher clouds give the finest coronæ is explained by the fact that such clouds, when composed of water, are made up of comparatively small and uniform drops. Ice clouds will produce halos, but never coronæ; hence the constitution of a cloud may be determined from the kind of optical phenomena it exhibits.

Another diffraction effect seen in clouds is known as "irization," and the clouds that exhibit it are said to be "iridescent." This consists of patches of color seen at various distances from the sun, differing from halos and coronæ in showing no signs of concentricity, but rather following the outline of the cloud. As a phenomenon of diffraction, irization must, according to Simpson, be due to water clouds and never ice clouds.

Simpson does not mention a third kind of clouds; viz., those formed of dust. These undoubtedly exhibit both coronæ and irization. The largest species of corona—Bishop's ring—is seen in clouds of volcanic or cosmical dust at enormous heights in the atmosphere, miles above the ordinary cloud levels. After the eruption of Krakatoa such dust clouds also exhibited striking irization.

Right and Left Hand Engines*

The Great Variety of Engines Now in Use Create Unexpected Complications

By W. H. Wakeman

THIS subject is not always understood by engineers and owners of steam plants. Apparently it is very simple, but closer examination and consideration of it shows that it is more complicated than it appears at first, because there is such a great variety of engines now in use.

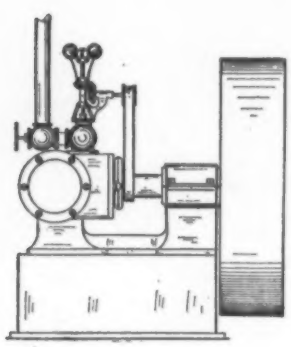


Fig. 1.

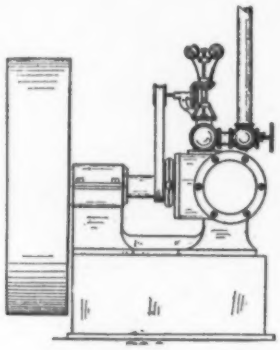


Fig. 2.

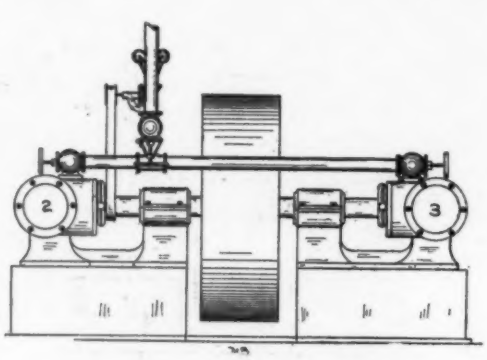


Fig. 3.

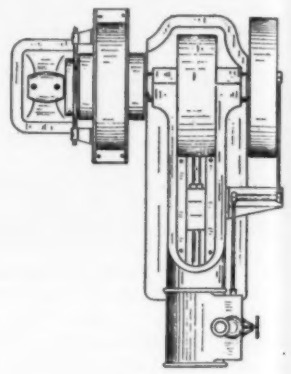


Fig. 4.

Fig. 1 is a right hand engine for the following reason: When standing at the cylinder end, facing the head as shown in the illustration, the valve gear and fly wheel are at the right hand.

Fig. 2 is the same kind of an engine, but the fly wheel is on the other side, hence it is a left hand engine. When corresponding concerning engines, it is necessary to understand these points, or else confusion and trouble results. If a man orders what he calls a right hand engine, to be erected in a suitable place, it is troublesome and expensive to receive a left hand engine, because the same standard was not adopted by both parties to the transaction.

Fig. 3 is a double engine, and it presents some interesting and novel features in this respect. When considered as a whole, 2 is the left hand cylinder and 3 the right, but when taken separately, as they must be when calculating on repairs, etc., 2 is a right, and 3 a left hand engine, for reasons already given.

Fig. 4 is a plan view of a high speed, direct connected engine. Inasmuch as the generator is at the left, it seems natural to call it a left hand engine, but this assumption is not correct. When we stand facing the cylinder head, the governor wheel and valve gear are at the right, hence it is a right hand engine. The direction in which the engine runs has no bearing on the case, as the points mentioned in the title of this article can be determined before the engine makes a revolution.

Fig. 5 is a simple, high speed engine fitted with two fly wheels on which belts may be used. The left hand wheel carries the governor, consequently the valve gear is also on this side, and it is known as a left hand engine.

Fig. 6 is a simple, center crank engine, fitted with two fly wheels, one of which is much larger than the other. As a belt may be used on either one or both of these wheels, the hand can not be determined from this feature. The eccentric, and other parts of the valve gear, also the governor pulleys and belt are at the left, hence it is a left hand engine. This would be the proper name even if there was no belt on the left hand wheel, and the right was used for the transmission of power.

Fig. 7 is a high speed, tandem compound, side crank, direct connected engine, fitted with a fly wheel on which a belt may be run to transmit power to shafting, or it may be used simply as a balance wheel. Part of the valve gear for the low pressure cylinder is on the right side, but for the high pressure it is on the left. The governor pulley and fly wheel are also on this side, hence it is a left hand engine.

Fig. 8 represents a high speed, tandem compound, center crank engine, fitted with two fly wheels for belts if desired. The valve for the low pressure cylinder, together with all gear that drives it, are on the left side. This includes a fixed eccentric on the crank shaft, as no automatic cut-off is provided for this cylinder. However, the entire gear for the high pressure cylinder is on the right side. The fly wheel on this side carries the governor, and when all of these features are considered, this is a right hand engine.

Fig. 9 is a high speed, cross compound engine fitted with two fly wheels, and what may be called two center cranks. If the term "center crank" meant that the crank is exactly in the center of the crank shaft, the above application of it would not be correct, but this is not the case, as when only a single crank is provided it is frequently far from the center. It only means therefore that a bearing is located on each side of it. The left hand cylinder is the larger, hence is the low pressure part, with the entire gear on this side. The governor and all parts of the high pressure valve gear are on the right, hence this engine when considered as a complete machine is a right hand engine.

Fig. 10 is a vertical, high speed, center crank, direct connected engine. It is viewed from the back, hence if it was to be laid down to represent a horizontal engine, the cylinder would be brought toward the reader. The governor pulley with its shifting eccentric would then be at the left, hence it is a left hand vertical engine.

Fig. 11 is a vertical, single cylinder, direct connected engine. It represents the front of the engine, or in other words the part on which the crank shaft is entered, as bearings are shown at 2 and 3. A generator appears at the left and a fly wheel at the right hand, nevertheless it is a left hand engine. This may be explained as follows: If this engine was to be turned down to represent one of the horizontal kind, the cylinder would be carried from the reader, and the part now shown would become the top. Then by standing at the cylinder end and looking toward the shaft the fly wheel and the governor are at the left hand.

Fig. 12 is a vertical cross compound engine, fitted with two fly wheels and direct connected to a generator. Both of these wheels are outside of the engine when considered as a separate unit, and the generator is at the extreme right. The front of this engine is shown, as 2, 3, and 4 are caps on the main bearings. The high pressure cylinder is at the left hand, and the governor is located in the left hand wheel when viewed

* Reproduced from *Practical Electricity and Engineering.*

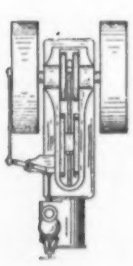


Fig. 5.

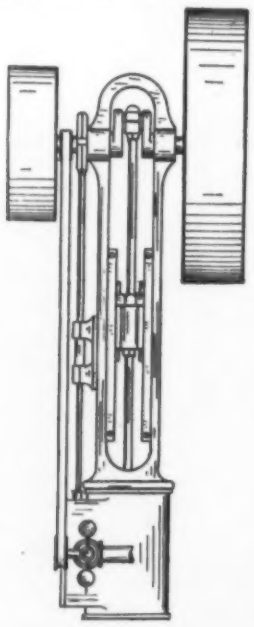


Fig. 6.

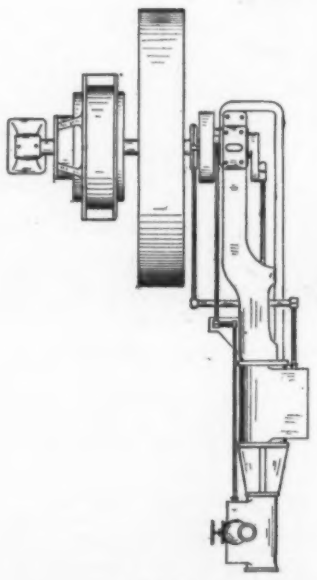
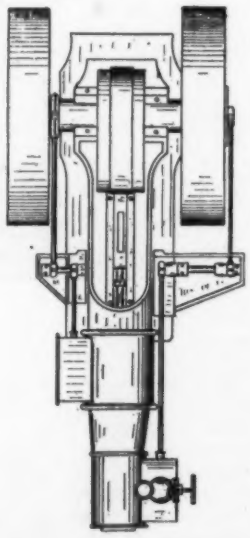


Fig. 7.



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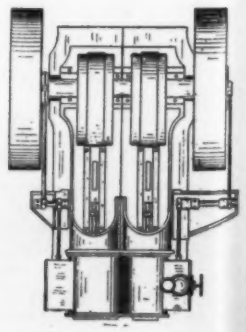

Fig. 9.

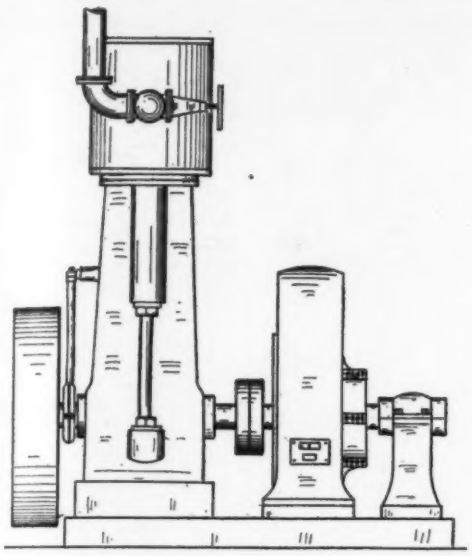

Fig. 10.

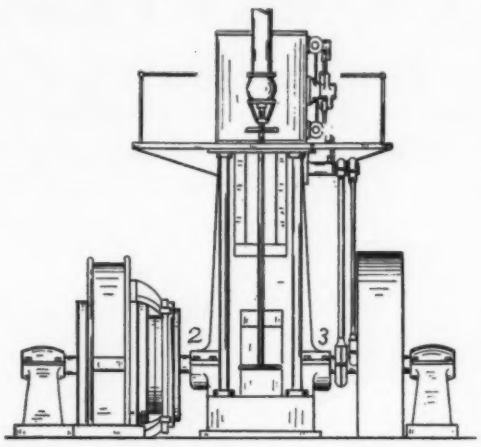

Fig. 11.

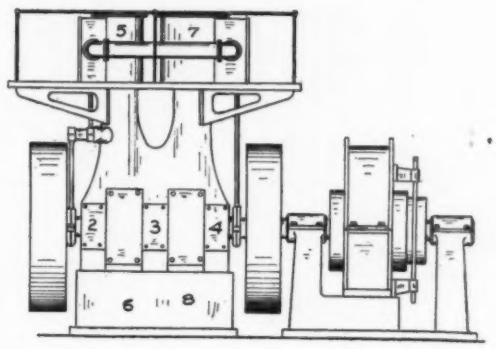

Fig. 12.

from the reader's standpoint. However, this is a right hand engine, because if it was laid down horizontally, and the observer stood facing the cylinder heads, the governor pulley would be at the right hand. The low pressure cylinder is also fitted with suitable valve gear, but it does not include governing mechanism.

I am aware that every engine builder does not follow the above mentioned rules, as some of them decide that what has been designated as a cross compound engine is really two engines connected to one shaft. Under this ruling, 5 is a right hand cylinder, the same as 3 in Fig. 3, but 6 is called a left hand engine, just as it stands in the illustration, 7 is designated as a right hand cylinder and 8 is called a right hand engine. This refers to a cross compound engine in which the high pressure cylinder is at the left, and the low pressure at the right hand. Reverse the position of these cylinders and the engines 6 and 8 would be left and right as before, but both are then called left hand cylinders.

In the case of Fig. 7 which shows a left hand tandem compound engine, the cylinders are both left hand. Fig. 8 illustrates a right hand tandem compound, in which both cylinders are right hand.

Fig. 13 is a vertical cross compound engine, with the high pressure cylinder at the right, and the low pressure at the left hand, as it appears in the illustration. They do not show as separate cylinders because the lagging is carried around both continuously. The wrist plate 2 operates the exhaust valves of both cylinders, and it is actuated by the fixed eccentric 3. The steam valves of both cylinders are operated from another wrist plate that is not shown, and this is driven by the movable eccentric, or governing device 4. If this engine was laid down horizontally, the cylinders would be carried from the reader, as the front appears in the illustration. This brings the steam valve gear on the lower side, which is unnatural but unavoidable. Applying a former rule shows that this is a right hand engine, just as it appears in its vertical form with all high pressure parts of the governing device at the right hand.

Fig. 14 is a vertical cross compound engine fitted with one fly wheel and two generators. This forms what may properly be called a well balanced machine, so far as these parts are concerned. The high pressure cylinder is at the left, the low pressure at the right, with the valve gear of both between them. While the governor is on the low pressure side, it operates the high pressure cut-off by means of suitable connections. The throttle valve 2 can be operated by the wheels 3 while standing on the platform, or by the extended valve stem carrying the wheel 4 from the engine room floor. This is very convenient when it becomes necessary to shut down quickly in an emergency.

This is an A vertical frame, hence the front is not easily determined, but as shown by location of the throttle valve, the front is shown in the illustration, hence if the engine was laid down flat, the cylinders would be carried from the reader. Then by standing facing the high pressure cylinder the fly wheel and governor are at the left, consequently it is a left hand engine.

Fig. 15 is two views of duplex pump. At the left the steam cylinders are shown and properly named. At the right the water cylinders are shown but in this case the reader is supposed to have moved around to the opposite end of the pump. Of course the left hand steam piston drives the left hand water piston, and the right side is operated accordingly, but it appears peculiar when illustrated.

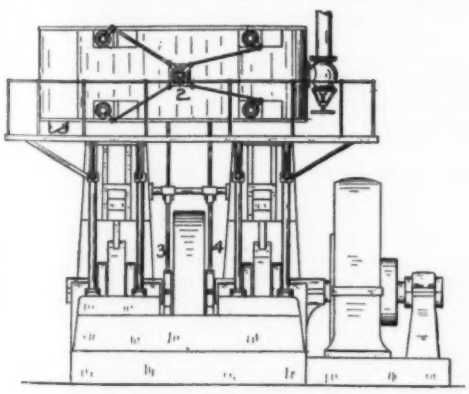

Fig. 13.

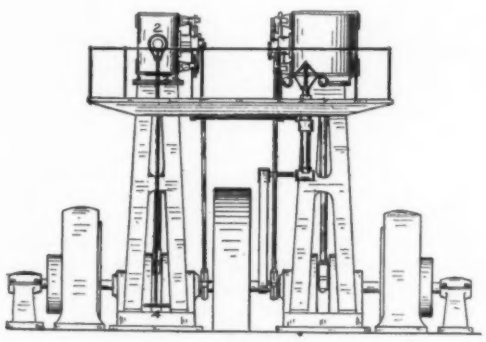

Fig. 14.

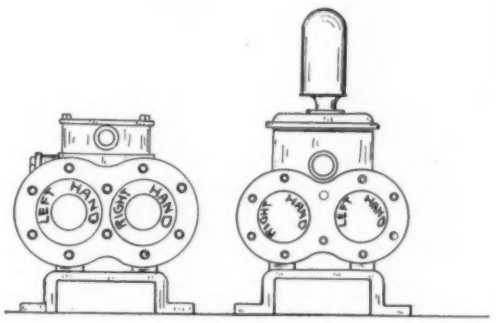

Fig. 15.

Stereoscopic Effects in Photography

THE exhibition of scientific photography which was recently held at Vienna in connection with the Austro-German Medical Congress contains, according to an article in the London *Times*, an exhibit which marks a great advance in the progress of photography. This is a series of photographs in which true plastic effect is obtained without the employment of a stereoscope or any other optical instrument. For the various objects depicted to stand out in their true relations to one another all that is required is that the picture should be looked at directly and not from one side or the other.

The method by which this result is obtained is, briefly, as follows: A double negative is made in the ordinary way by the use of a stereoscopic camera with twin lenses. Instead of the reconstruction by means of the stereoscope of the plastic image from the pictures thus obtained the inventors, Herr Friedmann and Herr Reiffenstein, have devised another means of making each eye see only one, and that one its own particular image. This consists of the application of the fact that when placed against a white background the image on a positive transparency is visible and that when seen against a black background it becomes invisible, while should the image be bleached the contrary is the case. From the negatives which have been obtained in the ordinary way with the stereoscopic camera are made, therefore, from one, an ordinary transparent positive, and, from the other, a negative which is afterward bleached. Let it be assumed that from the negative corresponding to the image seen with the right eye the ordinary positive is made and that the left eye's picture becomes the bleached negative.

If these two transparencies were super-imposed one upon the other and laid upon a white background only the right-eye picture would be visible. On the other hand, if placed upon a black background only the left-eye picture would be seen. It is, however, necessary that both eyes should see their respective pictures simultaneously. For this a background is required which to the right eye appears white and to the left eye black. This is provided by a sheet of glass, the back surface of which is prepared in a special manner, while the front surface is ribbed convexly, whereby the rays of light falling upon this surface are broken in such a way as to make it appear black or white according as looked at from one side or the other. The problem is, therefore, solved. The two transparencies are placed one upon the other and then both upon this background. The right eye sees only its proper image and the left eye likewise. These combine automatically, as is the case when a stereoscope is used, and the result is a true plastic picture.

The inventors exhibit five or six specimens of such photographs, to which they have given the name of "stereographs." Three of these appeared to the writer of this article to be almost faultless. One of them represented a lump of quartz in which even the shimmer on the surface was reproduced; another, a spray of orchids in a vase, and the third, the skeleton of a gorilla. In the other specimens the two images did not seem to combine easily. The inventors are making arrangements for the manufacture in cheap and handy form of "backgrounds" which they hope before long to have brought to such a state of perfection that the process will be generally employed. With such "backgrounds" the inventors state that pictures can be looked at like any other photograph. In the case of the stereographs now being exhibited, the effect of the black-and-white background is, however, obtained by a different method, which necessitates their being viewed by transmitted light.—*Science.*

Golden comb from tomb of Scythian king, fourth century B. C.

A Scythian Chief's Tomb Unearthed*

Intact After Two Thousand Years

By C. A. Bobrinskoy

The same. Its other side. Actual size and intact.

HISTORY affords us but a limited information concerning the Scythian tribes that inhabited the steppes of Southern Russia many centuries before the birth of Christ. The "father of History," Herodotus, tells us of the riches of the Scythian kings, their magnificent funerals and splendid tombs, gorgeously decorated with plate, jewelry and weapons wrought in gold. These ancient narratives have been fully confirmed by archæological research pursued in Southern Russia. Unfortunately, the majority of Scythian tombs are usually found in a state of complete devastation, having been plundered centuries ago by treasure-hunters. Occasionally, though, it does happen that the archæologist comes across an entirely unmolested tomb, or one that has been ravaged only in part, the plunderer evidently having been disturbed in his depredations. In this case the explorer has the pleasure of finding the remains and all the accessories of the burial rite just as they were deposited in the tomb, in the third or fourth century before the Christian era, at the time of the interment. In such intact sepulchres the archæologist finds a whole museum of antiquities of every kind.

A masterly account of the various discoveries made in the tombs of Scythian chiefs is given by Mr. Ellis H. Minns, M.A., in his splendid book on Scythians and Greeks, lately issued by the Cambridge University Press. The good fortune of opening an intact tomb fell to the lot of the author of these lines in June of this year. The excavation of an enormous tomb, a so-called "kourgane," bearing the name of "Soloha," had been going on during three successive summers under the direction of Professor Wesselowsky, a member of the Russian Imperial Archæological Commission, in the vicinity of the cataracts of the River Dnieper, in the northern confines of the Tauric government. After strenuous work on the part of Professor Wesselowsky, he succeeded in reaching the great central tomb. I joined him in the autumn of 1912, and we began a careful investigation of the entire subterranean structure which contained the central sepulchre of the "kourgane."

The tomb was dug out at a depth of eight meters (about 26 feet) under the surface of the earth, and this was surmounted by the earthen mass of the "kourgane," attaining the height of more than ten meters (about 33 feet) above the soil. Unluckily, however, the great central chamber had shared the general fate of most Scythian tombs, and had been entirely plundered at a date probably not far distant from the time of the interment, the plunderers leaving only some minute articles in gold and bronze and objects which evidently had no value in their eyes, as, for instance, a big bronze utensil, resembling a modern gridiron, supported by four small, though massive, wheels. (A similar object is displayed in the Etruscan Department of the British Museum.)

After the disappointment of finding the tomb desecrated, Professor Wesselowsky began to study the high earthern sides of the excavated parts of the "kourgane," and soon came to the conclusion that the mound concealed a second, lateral, tomb. After some months of continuous digging, this supposition proved to be correct, and in June, 1913, in answer to a second invitation from the explorer, I arrived at Wesselowsky's steppe encampment in the midst of an absolute desert, some ten miles from the nearest dwelling, and we experienced the great satisfaction of opening a Scythian chieftain's, or king's, tomb intact.

To reach this sepulchre we had to explore a great chamber apportioned to the king's horses, which we found placed in a row, five in number, and arrayed with multitudinous gold and brass ornaments, which formed parts of their harness and bridles. By the side of the horses lay the skeleton remains of a groom, and at the very entrance of the king's tomb another skeleton, evidently of a guard with bow and arrows. At the feet of the king lay a third man in a coat of mail with sword and brass arrow-heads.

The remains of the king occupied the center of a big chamber and were surrounded by various objects and weapons in bronze and iron, such as a coat of mail, two spears, arrows, swords, a big bronze mace with a wooden handle, and a splendid bronze helmet. By the king's side lay a big sword in a magnificent gold sheath, with figures of lions, dragons, etc., worked upon it in relief. Round his neck was a heavy gold necklace ending in lions' heads richly inlaid with multi-colored enamel. Near his elbow lay another gold necklace, and his arms were encircled by numerous gold bracelets. On the right of the king stood five silver vases, some of which were covered with beautiful engravings presenting scenes of Greek indoor life and of mounted Scythians fighting wild animals. These figures are gilded and attest the skill of some great artist.

The king's robe was covered from head to feet with small golden plaques, presenting various designs: Scythians drinking out of the same horn, griffins, lions, deer, etc. At some distance from the skeleton we found a number of bronze cauldrons, containing bones of oxen, sheep, etc.; also a series of earthenware; big amphoræ for wine and oil, bearing painted Greek letters, small vases and so on. Around the deceased were placed various other utensils, ornamented with gold.

Near the king's head, the earthen wall of the tomb contained a special hiding-place, neatly plastered up with clay. In this niche we found two splendid objects, one of which is a massive gold dish (called in Greek "phialé"), richly covered with relief representations of lions and deer. A very faint Greek inscription, running around the edge of the plate, bears the names of Antisthenes and Antilochus. The other article concealed in the niche was a quiver with a great number of fine bronze arrow-heads. The wooden sheath of this quiver was covered with plaster and silver, and engraved with a battle-scene. This beautiful piece of Greek workmanship has, unfortunately, been totally ruined by the action of time, and it took no end of patience and care to reconstruct the fragments, so as to obtain a more or less satisfactory idea of the scene of battle. This picture gives us a most interesting series of figures of bearded Scythians fighting each other.

The same sort of scene, a fight between three warriors, one of whom is on horseback, the others on foot, forms the upper part of a big, massive golden comb, one of the most splendid articles of antique Greek jewelry that exists. This comb lay at the king's right side, near his head. Our photograph speaks for itself and hardly needs any detailed description. We should only like to remark that this photographic representation gives but a poor idea of the magnificence of the comb. This object is absolutely intact and might have come direct from the artist's workshop. The figures are finished up to the smallest details, so far even as to give each face of the little golden warriors a separate expression. The precision and details of each piece of armor are marvellous. The comb lay on the earthen floor of the tomb, and when we first touched it with our small shovel, the earth that covered the comb easily gave way and the splendid jewel burst upon us in all its glory.

Such a unique piece of art will certainly attract the attention of men of science, antiquaries and artists. But, before concluding this description, I beg the reader to transport himself in imagination to the steppes of "Soloha," and to conceive the thrilling emotion which we experienced when first we beheld this wonderful example of the goldsmith's skill, and our hands raised this royal jewel, ours being the first human contact after more than two thousand years.

* Reproduced from the *Illustrated London News*.

A quiver, showing battle scene, found hidden in a niche in the wall of the king's tomb. Actual size.

A Monument to Balboa.—The Spanish-speaking countries of the world are uniting in raising funds toward a splendid monument to Balboa, the discoverer of the Pacific Ocean, to be erected near the Pacific entrance to the Panama Canal. King Alfonso, of Spain, has made a personal donation of $10,000 to the fund; the republic of Panama will contribute a like amount; and it is hoped that the total fund will reach $175,000.

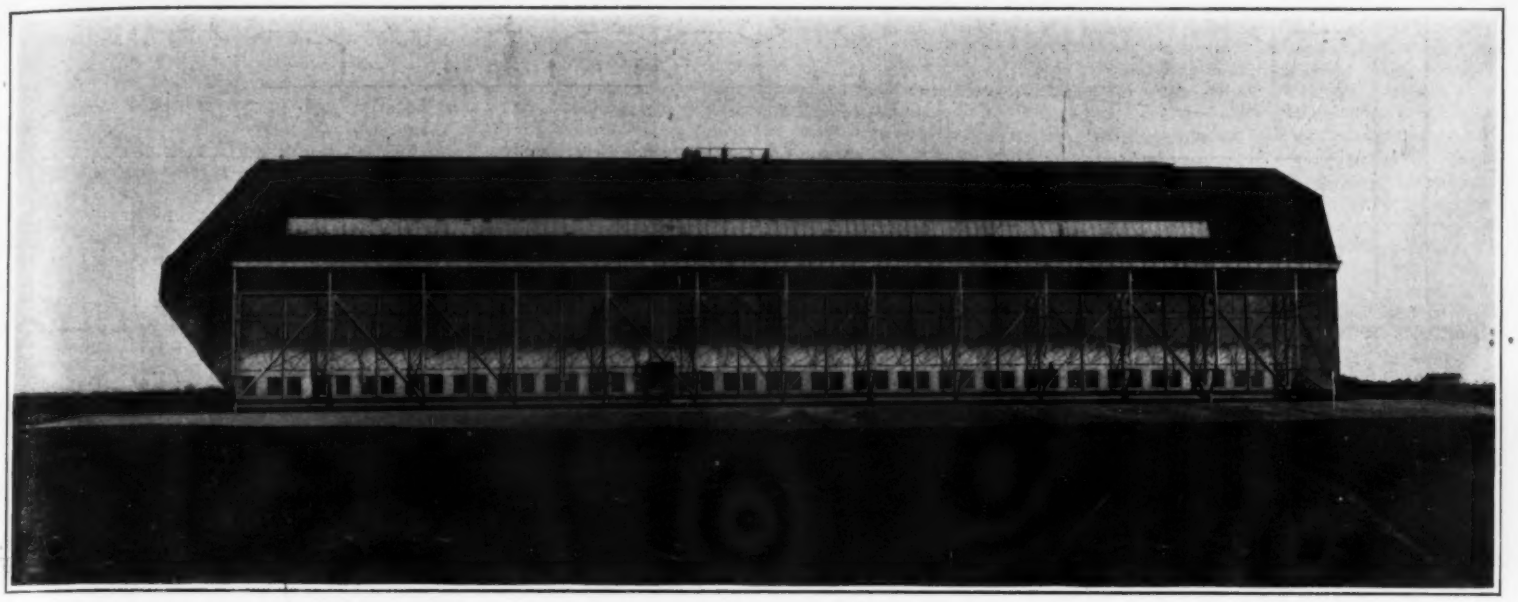

Fig. 1.—Electrically operated turning airship shed for a Krell airship of Siemens-Schuckert Werke, Germany.

Rotating Airship Shed

Safeguarding the Dirigible Against Damage in Landing and Re-entering

THE difficulty of returning a modern airship to cover in a stationary shed with a strong wind blowing (unless it just happens to come from the right quarter) has resulted in the development of an electrically-operated airship shed by Mr. Krell of Berlin. Views of this are shown in the accompanying illustration (Fig. 1) and drawings (Figs. 2, 3 and 4) and the details of construction and method of operation of this structure are of special interest.

The difficulties arising from the use of a stationary airship shed are clearly indicated in the accompanying illustration (Fig. 1) which shows such a building on the banks of Lake Lucerne, Switzerland, where an aeronautical park has been established. This structure was of large dimensions, designed to accommodate two dirigible balloons of the type shown in service in the diagram, Fig. 4, for protecting them against the effects of bad weather when not in service.

The passenger service over Lake Lucerne, Switzerland, was intended to give the tourists in the air short trips to better view the incomparable Swiss scenery and give them the benefit of a taste of the new sensation of aerial navigation.

The airship "Ville de Lucerne," a cigar-shape dirigible balloon, was constructed with tail rudder designed to increase the stability of the airship. The latter was furnished with a nacelle 66 feet in length, constructed with steel tubes, of quadrangular cross section, and provided with a cabin for the passengers and crew in the central part.

This airship, which is of the non-rigid type, was constructed with a diameter of 40 feet, and measured 198 feet in length, with a capacity of 15,900 cubic feet of pure hydrogen gas. The airship "Ville de Lucerne" was built to carry a dozen passengers, with ballast and gasoline for a voyage of five hours, reaching altitudes as high as 5,000 feet above the sea level, without risk. It was equipped with propellers driven by a gasoline motor of 100 horse-power capacity, having four cylinders. This gasoline motor was constructed with a long longitudinal shaft directly connected to the propeller, the latter having two blades, measuring 16.5 feet in diameter, and operating at a speed of 400 revolutions per minute. The propeller was so arranged that it could be disconnected from the motor by a clutch or thrown in gear without difficulty on account of its moderate speed.

The "Ville de Lucerne" was equipped with floats, attached to the bottom of the nacelle or body and making it possible for the airship to alight on the surface of Lake Lucerne and float smoothly on the water, ready to start on a new flight at any time desired.

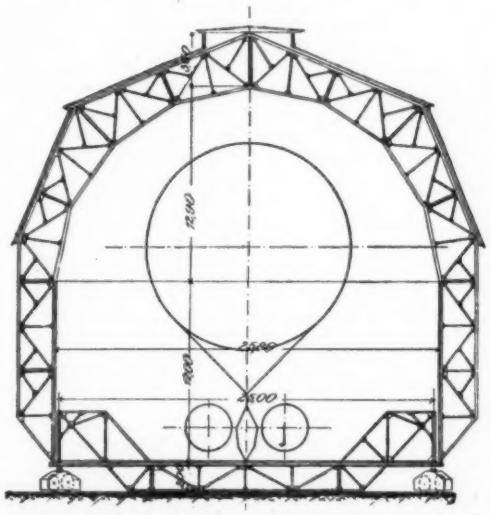

Fig. 2.—Section of Krell airship and movable shed.

Anyone who has had an opportunity to watch a large airship being taken out of the shed will readily appreciate the importance of an arrangement whereby the shed can be turned in the most favorable direction with regard to the wind. The great success of the electrically-operated turning airship shed here described is clearly indicated by the fact that the Krell non-rigid airship made sixty-two successful ascensions up to March 9th, 1912, in all kinds of weather, attaining a maximum speed of 44 miles per hour.

This huge airship shed normally turns at a speed of 360 degrees per hour, although it may be rotated more rapidly if desired, and it has been found practicable to make a landing of the airship at a speed of 33 feet per second (22 miles an hour) without difficulty.

The structure measures 427 feet in length and 78 feet in width, with a total weight of 1,200 tons, carried by 24 wheels on the circular track. As indicated in the drawing (Fig. 4), this huge non-rigid airship is similar to a torpedo in shape and measures 390 feet in length, with a width of 50 feet, the displacement being about 500,000 cubic feet.

It will be noted at the left in Fig. 4 that there is an underground chamber provided, capable of holding 3,000 steel cylinders of hydrogen gas under high pressure for filling the envelope when desired.

The Krell airship has three cars, the center one being provided with two internal combustion engines of 24 horse-power capacity each, driving air-blowers for supplying the necessary air pressure to the three balloonets, although only one motor is utilized at a time, the other unit being held in reserve.

For driving the airship each of the end cars is equipped with two Daimler motors of 125 horse-power each, one of which is direct-connected to a four-bladed propeller, operating at a speed of 750 revolutions per

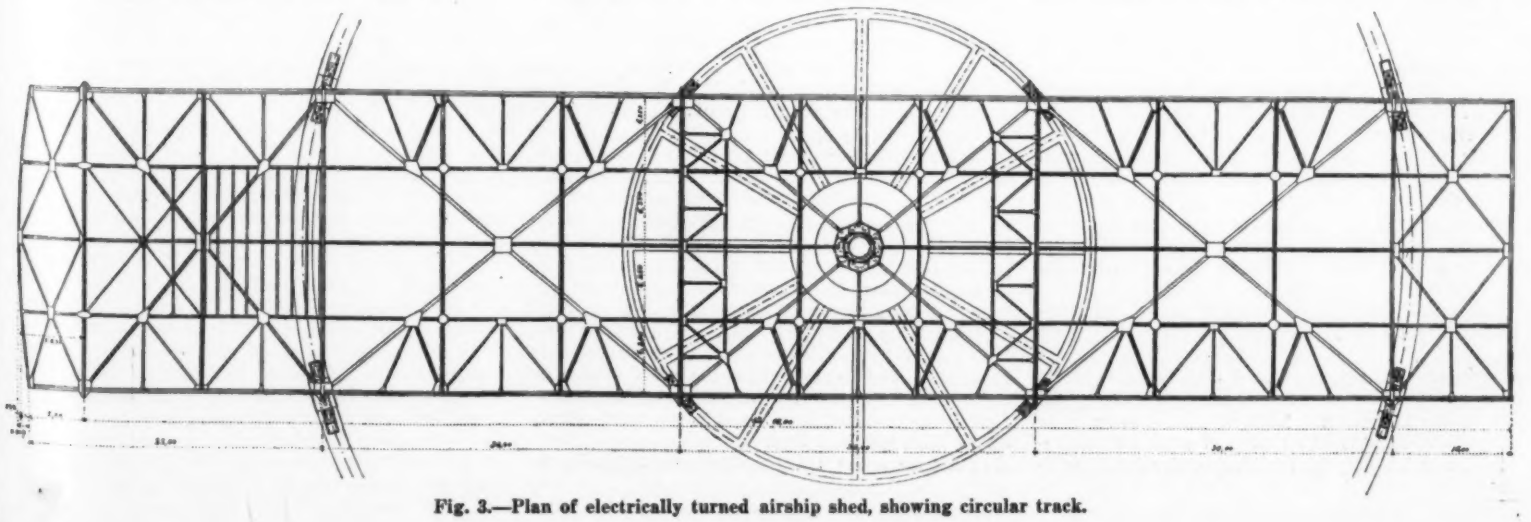

Fig. 3.—Plan of electrically turned airship shed, showing circular track.

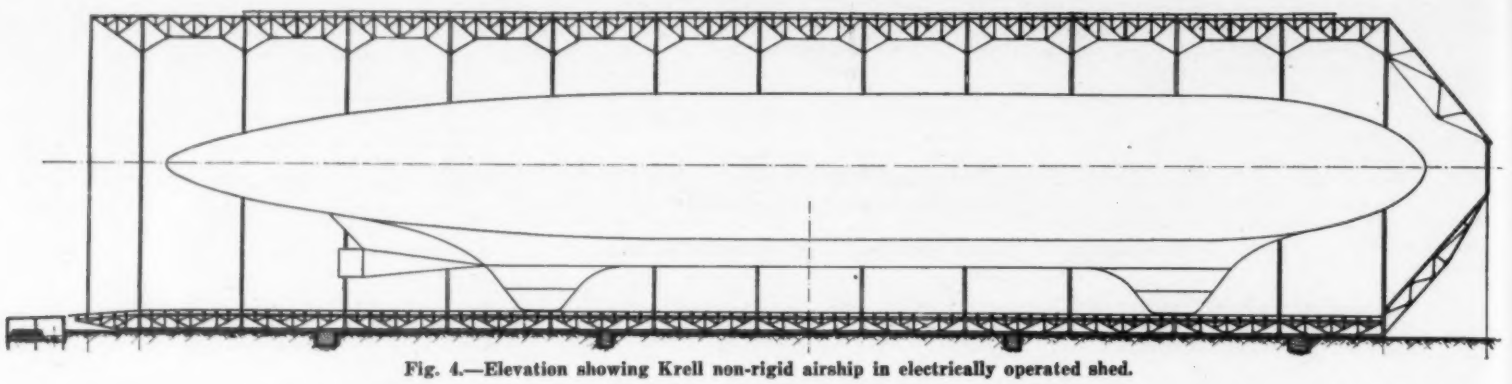

Fig. 4.—Elevation showing Krell non-rigid airship in electrically operated shed.

minute, while the other motor drives two two-bladed propellers at a speed of 700 revolutions per minute. It will thus be seen that the airship has a total engine capacity of 500 horse-power.

The electric power equipment of the airship shed consists of two motors of 40 horse-power capacity, direct-connected to 24-kilowatt, direct-current dynamos, operating at a speed of 1,000 revolutions per minute, one of these generators together with an 8-kilowatt, 110-volt exciter dynamo being mounted on the extension shaft of each engine. These engines are four-cylinder machines and are started by electric power from a storage battery by one of the direct-connected dynamos.

The storage battery plant consists of 60 cells of accumulators, having a capacity of 481 ampere hours at a one-hour discharge rate and 576 ampere hours when discharged in two hours. This direct-current gasoline motor-generator equipment operates on the Ward-Leonard system of control for electrically actuating this huge airship shed. There are in all six electric motors used for turning the structure. Each of the four axle trucks or trolleys is equipped with two electric motors of 10 horse-power capacity, operating at a normal speed of 560 revolutions per minute, geared to a driving wheel 3.3 feet in diameter.

The current from the storage battery is sufficient to operate these electric motors for turning the shed for two hours at night without totally discharging the accumulators, so that it is unnecessary to operate the engine at night.

For lighting the airship shed there are seventy-two tantalum lamps installed, forty-eight of which are of 32 candle-power each, placed at the side at a height of 10 feet, while twenty-four 50 candle-power lamps are suspended in two circles in the upper part of the shed.

This electrically-turned airship shed is located at Diesdorf, Germany, and represents what is claimed to be the most perfect system so far devised for housing large airships, and it would seem that this contention is borne out by the fact that more than threescore ascensions have been made without the slightest difficulty being encountered in entering and leaving this protected airship shed and in moving the huge structure as desired so as to allow for any direction of wind when the airship is engaged in returning to or leaving the building.

Lead Poisoning in American Industrial Life*

The Danger and Its Prevention

About 150 of our industries make use of lead in some form or other, and thousands of American workers are therefore exposed to the industrial disease that is variously known as "lead poisoning," "plumbism," "saturnine poisoning," and "leading." This malady, to which workers of all ages and both sexes are susceptible, is in fact one of the most widespread and important of the ailments that are due to occupational causes. Every good citizen should be interested in hastening sound and sane reforms that will tend to lessen its effects.

Lead has caused more deaths than any other metal, partly because it is so generally used, and partly because its effects upon the human organism are insidious, so that they often escape detection in the early stages. In the form in which it is encountered in most of our industries, plumbism is a cumulative disease, resulting from the continued entrance of minute quantities of lead into the system. It may be contracted in various ways, but it is most commonly due to swallowing traces of lead compounds, or to inhaling fumes or dust containing them.

The evil effects of lead have been known for centuries. Vitruvius condemned the use of lead pipes for the conveyance of water, and Pliny recognized the danger to which lead workers were exposed in his time, referring to the poisoning as "slaves' disease." (The process still widely used for the manufacture of the best grades of white lead, and known as the old Dutch process, is almost identical with that used in Greece and Rome in the days of their greatest industrial activity.)

Lead is harmful not only to man, but also to animals of all kinds. The potters of Hungary, many of whom carry on their work in their homes, cannot keep singing birds in their houses, and their domestic fowls die in large numbers from feeding in the door-yards where splashes of the dried lead-bearing glaze have fallen. Dogs and cats are also extremely susceptible to the poisonous effects of lead. Lead-smelting works are usually located in remote, thinly-settled districts, partly because vegetation is rapidly destroyed by the fumes that they give off; and owners of smelters in Scotland and in other countries have been compelled to pay considerable sums of money to farmers in the vicinity to compensate them for ruined crops and lead-poisoned cattle.

The United States is far behind other civilized countries in dealing with industrial lead poisoning. Most of the countries of Europe have enacted laws which regulate the sanitary condition of manufacturing plants using lead or its compounds, and which prescribe special precautions in connection with processes known to be dangerous. Reports of all cases of plumbism are required, and these reports furnish extensive data respecting the amount of sickness among lead users, and determine accurately the benefits derived from improvements in the methods and conditions under which they work. In our own country we are mainly dependent for information of this kind upon the necessarily incomplete records of hospitals and dispensaries, upon the memoranda of attending physicians, and upon the statements of workers who are constantly shifting from one location to another, and who are largely uneducated foreigners.

Most of the methods that are employed in European countries for safeguarding lead workers may be successfully applied in this country also. The States of California, Connecticut, Illinois, Michigan, New York and Wisconsin have enacted laws requiring physicians to report all cases of occupational diseases, and Ohio, Pennsylvania and Missouri have quite recently enacted laws, similar to those now in force in Europe, for the protection of lead workers. With these exceptions, we have practically no legislation on the subject.

Great Britain has been studying the lead-using industries for more than twenty years, and has succeeded in effecting a striking decrease in the amount of sickness associated with them. A recent careful medical examination of 182 men, in an English white-lead factory, failed to disclose a single case of lead poisoning during the year 1909–10; and for five consecutive years, in another English factory, no case was reported among the 90 men employed. Some of the methods that were used in bringing about these salutary conditions are described by Sir Thomas Oliver in the following passage: "Abolition of female labor in the dangerous processes of white lead manufacture, insistence upon personal cleanliness on the part of the workers, the better provision by employers of washing appliances, prohibition of eating and drinking in the factory, and periodical medical examination of the workers, have materially reduced the sickness and mortality rates in the lead industries. In the manufacture of pottery alone the sickness rate has fallen 70 to 80 per cent."

Some statistics compiled by Dr. Hamilton and published by the United States Bureau of Labor will show to what an alarming extent plumbism has become prevalent in our own country. Dr. Hamilton reports that in 23 out of 25 lead factories in this country, employing approximately 1,600 men, 358 specific cases of lead poisoning were discovered, and 16 persons died from this cause between January 1st, 1910, and April 30th, 1911. In the State of New York, during the years 1909 and 1910, physicians reported 60 deaths from plumbism. Data collected for the years 1909, 1910 and 1911 showed 376 cases of lead poisoning in New York city alone, and 578 cases of it occurred in Illinois during 1908, 1909 and 1910.

In a later report Dr. Hamilton states that in the establishments visited during 1910 and 1911 there were 60 cases of lead poisoning among the 796 male persons employed in 40 white-ware potteries, and among the 150 women who were employed in the same works, 43 cases developed. In potteries making art and utility ware, and in tile factories, the disease was even more prevalent. During 1910 and 1911, 63 cases were noted among 304 male employees, and 35 cases among 243 women workers. In the industry of coating iron hollow-ware with porcelain enamel, 309 cases were found to have occurred among 1,012 employees within a period of two years; and out of 148 enamelers and mill hands who were examined, 54 were found to be suffering from chronic lead poisoning.

The Bulletin of Labor of the State of New York reports 125 cases of lead poisoning in all industries during the twelve months ending with August, 1912; 8 of them ending fatally.

Lead poisoning is most prevalent among the workers in white-lead and red-lead factories, and among the employees in potteries; but stereotypers, employees in storage battery plants, tinsmiths, house painters, polishers of glass and of precious stones, file cutters, and workers in many other industries are also subject to it. Women are more susceptible than men, and in them it is more likely to assume the worst form—namely, the cerebral type, technically known as "saturnine encephalopathy." Young adults of both sexes are quicker to succumb than those who are older. Intemperance in the use of alcoholic drinks predisposes to plumbism, as has been proved by the greater number of cases occurring in districts where the use of alcohol is general.

One of the first symptoms of plumbism is a disagreeable metallic taste in the mouth, which is experienced by the lead worker upon getting up in the morning. He fails to enjoy his breakfast, suffers from headache, and feels generally indisposed. Severe attacks of colic, accompanied by vomiting, are experienced at a somewhat later stage. The seizures may be paroxysmal in character, or the pain may be constant and of such an agonizing intensity that at times it is almost impossible to restrain the sufferer. A most careful diagnosis is often necessary to distinguish between lead colic and appendicitis. The symptoms of the two are closely similar, and it is known that persons have been subjected to the risk of surgical operation at times when medical treatment would have been sufficient.

A peculiar pallor of the face is noticed in the patient as the diseases progresses. This is due partly to the fact that the lead causes a great diminution in the number of red corpuscles in the blood, and partly to a coincident contraction of the superficial blood vessels of the body. A distinct blue line—known as "Burton's line"—is usually found upon the gums near the base of the teeth. Lead also acts directly and indirectly upon the kidneys, the liver, and the nervous system. Its action upon the nervous system commonly results

* Reproduced from the *Travelers' Standard*.

in "wrist drop," the muscles of the fingers, hands and wrists becoming paralyzed so that the hands hang limp and powerless. The ankles are often affected in a similar manner, making the patient entirely helpless.

As has been stated above, lead poisoning of the brain, or saturnine encephalopathy, manifests itself most frequently in women. This form of the disease may give no other warning than a severe headache, but the sufferer is later seized with convulsions, and passes into a state of coma during which death may occur. If the patient recovers consciousness and lives, loss of vision, either temporary or permanent, sometimes occurs.

Remarking upon the special susceptibility of women to lead poisoning, Sir Thomas Oliver says: "After a few weeks' exposure to lead in a white-lead factory I have seen young, healthy women not only lose their ruddy appearance and become quickly pale, but die from saturnine encephalopathy within four months of taking up work."

In smelters the chief danger lies in the fumes that are given off from the furnaces, and in the dust that collects in the long flues through which the fumes pass before escaping into the open air. These flues are cleaned periodically, and as the dust is composed almost exclusively of oxides and sulphate of lead, the cleaning operation is especially dangerous. In fact, if the passages are not freely ventilated it is impossible for men to continue at the work longer than two hours at a time, without becoming poisoned. A considerable quantity of lead could be recovered from the fumes that rise from the furnace by passing them through water under pressure. This would diminish the hazard to the workmen, and it would also result in a saving to the manufacturer.

In making red lead the fumes and dust resulting from the various processes constitute serious sources of danger, and in the preparation of white lead, especially by the widely-used old Dutch process, large quantities of dust are also raised. Pottery and earthenware manufacture is productive of many cases of plumbism by reason of the dust that is produced in the glazing process. It is possible to use a leadless glaze in the manufacture of certain kinds of earthenware; and in other branches of the pottery industry, where the use of such a substitute seems to be impracticable, other precautions may be taken which will greatly diminish the danger to the workers.

Employees in storage-battery manufacturing plants are exposed to lead poisoning by the handling of a paste composed of red lead and sulphuric acid, which is used in the preparation of the electrodes. Other processes connected with this occupation also contribute to its dangers. The serious nature of the hazard is shown by the case of a factory in Vienna, employing 107 men, which reports that from 4 to 5 of its men, on an average, are usually out, each day, on account of attacks of plumbism.

Dangers similar to those we have described are associated with all of the approximately 150 industries in which lead is used. To eliminate the exposure to noxious dust and fumes as far as possible, the machinery should be enclosed, manual labor in the dusty processes should be dispensed with, and mechanical mixers and conveyors should be employed wherever they are practicable. Thorough ventilation of all the rooms and buildings in which dust and fumes may collect is also of fundamental importance. All furnaces should be hooded, and fans or other apparatus for carrying off the poisonous fumes should be installed. Respirators should be provided for the men. Plentiful supplies of hot and cold water, soap, nail brushes and towels should also be furnished, and care should be taken to see that they are frequently and faithfully used. Lockers should be provided for the street clothes of the workers in a room entirely separated from the workplaces, and the employees should be provided with overalls and jumpers and with some effective form of head covering to protect the hair. A regular weekly examination of all employes should be made by a competent physician, who should give immediate treatment to every person showing symptoms of poisoning. Warning signs, printed in all the languages spoken by the employees, should be conspicuously posted in every workroom, and as some of the workers are not able to read even the language that they speak, reliable interpreters should be provided to give such men oral instruction concerning the dangers of their work.

To secure the best results from the regulations here suggested, it is essential for the workers themselves to do everything possible for their own protection. They must be particularly painstaking in regard to personal cleanliness, and they must refrain absolutely from the use of tobacco while in the workplaces. They must eat only in the rooms that are reserved for that purpose, and before eating they must thoroughly cleanse their hands and faces from every particle of lead dust. All outside garments should be changed before entering the workrooms, and again before going home at night; and under all circumstances it should be remembered that in the effort to prevent poisoning in our lead-using industries, *absolute cleanliness*, even to the verge of apparent absurdity, is the keynote of success.

The Radioactive Disintegration of Sodium as an Element

By Prof. F. C. Brown, Ph.D.

By the usual test for radioactivity, i. e., the continued ionization of a gas independent of other physical conditions, sodium as an element does not display any activity that is definitely greater than that found in all matter. And the ionizing activity of ordinary matter is so slight that it cannot be stated with definiteness whether or not the matter is of itself radioactive. But radioactivity implies a more fundamental change than that of emitting matter and energy continuously. It implies an atomic disintegration. If α particles are emitted the atoms go by leaps and bounds to new atoms of other properties, while if β and γ radiations are emitted the wearing away of the atoms must be just as certain, though no one has been able to conjecture by what steps the changes may take place.

The fact that a given element does not give out a measurable ionizing radiations is not necessarily evidence that it is not radioactive. For example we may note the case of Radium C, which gives no measurable radiations. Yet it disintegrates or decays to half value in forty years. It is, therefore, known as a radioactive element.

If sodium is a radioactive element we may at present look for other evidence than direct radiations. We shall inquire whether in past geologic time sodium has accumulated radioactively from other matter or on the other hand whether sodium has disappeared or disintegrated into other forms of matter.

THE EVIDENCE FROM GEOLOGY.

The best evidence that we have for considering sodium a radioactive element is from geology. If the age of the earth is determined from radioactive data, and the value accepted, we find that there is not accumulated in the ocean basin as much sodium as there would have accumulated during this time.

Different authorities give the age to range between seventy million and one hundred million years. On the other hand the data of radioactivity gives the age to be about ten times as much as the figures noted above. The principles of the radioactive method are based on the determination of the amount of helium or lead associated with known quantities of uranium in rocks of different epochs. The two principal assumptions that are involved are that during the age in question the amount of the uranium and its products, which give rise to helium shall have remained constant, and that the rate of production of helium shall have remained unchanged. Naturally these two assumptions cannot be proved. It can only be said that there is no evidence that casts suspicion on these assumptions.

According to experiments by Rutherford and his colleagues, one gramme of uranium in equilibrium with its products gives 10.7×10^{-8} cubic centimeter of helium per year. Now, if we examine the rocks of the different geological epochs, we find the rare gas helium inclosed in the rock wherever uranium is found, and further the older the rocks the greater is the amount of helium associated with each gramme of uranium. Obviously, if we divide the total amount of helium per gramme of uranium by the above constant, 10.7×10^{-8}, we obtain the number of years during which the uranium has been depositing helium, i. e., the age of the rock containing the uranium.

The greatest chance for error in the above methods of calculation lies in the possible escape of helium from the rock containing the uranium. Therefore, the age of the rock as calculated might be too small. The method would, therefore, set a minimum limit on the age of the earth.

But if we accept Boltwoods' conclusion, that the lead associated with uranium in rocks resulted from the radioactive disintegration of the uranium series of elements, and that one gramme of uranium gives rise to 1.88×10^{-11} gramme of lead per year, we have a check upon the results obtained with the helium deposit. In general the lead deposits give a somewhat larger age for a given rock than do the helium deposits, which is what we should expect if the helium may escape.

Using the method outlined above, Rutherford in 1906 found the age of a sample of fergusonite to be 240,000,000 years. This was deduced as outlined from the fact that 1.81 cubic centimeter of helium was taken from one gramme of the mineral which contained about 7 per cent uranium.

Strutt by the same method found two stones from Quebec of the Archæan age to be 222 and 715 million years old, and two of the same kind from Norway to be 213 and 449 million years. He also found the average minimum value for Haematite of the Eocene period to be 31 million, the same from the carboniferous period limestone to be 150 million years, while for the Archæan age the average was 710 million years.

Holmes, using as a basis the ratio of the lead to the uranium in the rocks, found the values given in the following table:

Period.		Age.
Carboniferous		340,000,000 years
Devonian		370,000,000 "
Pre-carboniferous		410,000,000 "
Silurian		430,000,000 "
Pre-Cambrian	Sweden	1,025,000,000 "
	United States	1,310,000,000 "
	Ceylon	1,640,000,000 "

The above results show that the age of the earth in its present form must be many times a hundred million years.

However, if we take the evidence as based on the result that is obtained by dividing the total amount of sodium in the ocean by the annual output of all the rivers of the globe, we find that the age of the ocean cannot be more than one hundred million years. Two of the most eminent geologists, F. W. Clarke and J. Joly, think that 70,000,000 years is much more nearly the correct age, based upon the solvent denudation of sodium.

There is, therefore, a discrepancy between the age of the earth as deduced by the two methods. Joly, in the *Philosophical Magazine* for September, 1911, favors the view that the radioactive constants are probably in error, because they have not been taken from data extending over a sufficiently long time, and under proper circumstances free from doubtful assumptions.

I wish to suggest that there is another explanation of the discrepancy that requires no distrust of the radioactive constants as they have been experimentally determined. In fact, the explanation is merely an extension of our knowledge of radioactivity to a wider field. The discrepancy disappears if sodium is supposed to be a radioactive element. If we accept the present data of radioactivity as authoritative, then it must be admitted that there is not enough sodium in the ocean. Perhaps during geologic time elements of higher atomic weight may have been disintegrating into sodium, and, therefore, the annual output of the rivers now is not the average output for all time in the past. That is, the sodium over the land has been increasing by radioactive production while sodium in the ocean has been increasing almost entirely by the annual river supply. Obviously this would give a greater age for the ocean. Or perhaps the average amount of sodium discharged annually to the ocean has not changed markedly, but the sodium in the ocean has been very slowly disintegrating into other elements. It seems that our present information is not sufficient to decide which of these two views is most plausible. Either condition is in agreement with an earth of older age. Both conditions may have prevailed, and both ideas are directly in line with recent progress in science. Either is in agreement with further facts as presented by geochemistry.

FURTHER EVIDENCE IN GEOLOGY INDICATING THE DECAY OF SODIUM.

There are other soluble elements than sodium carried to the ocean by rivers, which indicate quite a different age of the earth, and consequently favor the radioactivity of sodium. Only those elements that are not deposited in the ocean bed or otherwise removed from the ocean water may be considered for reliable information. Clark in his "Geo-Chemistry," second edition, p. 125, gives the following facts; the last column are my own deductions, however.

	Annual output from rivers, metric tons $\times 10^9$	Amount. in the ocean, metric tons $\times 10^{12}$	Age of ocean.
Chlorine..	155,350	25,538	160×10^6
Sodium...	158,357	14,138	89×10^6

The geologists do not believe that the rivers carried on the average any less sodium previously than they do now. But if they did, they should also have carried less chlorine. We may, therefore, for checking purposes say nothing concerning the annual river output further than that it should have varied alike with sodium and chlorine. On this assumption the above figures show that there is not as much sodium in the ocean as there should be. Disregarding the radioactivity data altogether, we see that the above evidence favors the radioactive decay of sodium as an element. Clarke goes on further to state, "We can understand the accumulation of sodium in the ocean and some of the losses are accounted for, but the great excess of

chlorine in sea water is not easily explained. In average river water sodium is largely in excess of chlorine; in the ocean the opposite is true, and we cannot help asking whence the halogen element was derived. Here we enter the field of speculation and the evidence upon which we can base an opinion is scanty indeed."

My comment on Clarke's statement would at once give an explanation of the excess of chlorine over sodium in sea water. It is, that if the chlorine has accumulated and disintegrated in the ocean it has been at a much slower rate than has been the disintegration of sodium in the ocean or slower than the decay of the parent of sodium where it was derived from the land.

It is obvious that whether we consider the radioactive data or only the data of geo-chemistry, that it is convenient to assume sodium to be a radioactive element. There has been proposed by no one any other common explanation for the discrepancies to which attention is called in this paper. However, it may be noted that the age of the earth as calculated from the chlorine in the ocean is yet much smaller than that given by the radioactive data. I do not believe this discrepancy detracts from the argument as presented.

Energy Sources of the Future*

As the civilization of to-day is absolutely dependent on the energy stored up in the coal beds many thousands of years ago it is of interest to determine whether our descendants will possess any adequate substitute for this source of energy, when it shall have been exhausted.

The quantities of coal mined in various countries in 1909, expressed in millions of tons, were as follows: United States, 402.0; Great Britain, 268.0; Germany, 217.4; all other countries, 209.9. The total amount for the whole world, therefore, is 1,097.3 million tons which, assuming the heat of combustion to be 6,000 calories per kilogramme, would produce, in burning, 6.6×10^{15} calories. The quantities of mineral oil produced in 1909, also expressed in millions of tons, were: United States, 23.0; Russia, 8.6; Austria-Hungary, 1.7; Rumania, 1.1; all other countries, 2.8. The total is 37.2 million tons, which, assuming the heat of combustion to be 10,000 calories per kilogramme, would produce, in burning, 3.7×10^{14} calories. The total amount of energy obtained from fossil fuel in 1909, therefore, was about 7×10^{15} calories.

For some purposes it is preferable to evaluate our consumption of fuel in mechanical, rather than British thermal units. A modern steam engine consumes, for each horse-power developed, 500 grammes of coal per hour, or 4.3 tons per year. The corresponding quantities for a motor using liquid fuel, in the most favorable conditions, are 200 grammes and 1.7 tons. Hence the coal and oil mined in 1909 would suffice for the production of about 270 million horse-power continuously throughout the year.

The substitute for mineral fuel that first suggests itself is "white coal," or water power, which already is utilized very extensively, with the aid of the most improved technical appliances. An accurate valuation of the aggregate available water power of the globe cannot yet be made, but it is possible to form an approximate estimate and to assign a superior limit with certainty.

More or less thorough surveys of water power have been made in many lands, including Switzerland, Norway, Sweden, France, Italy, the United States and Canada. The most complete data accessible are those of Switzerland, where the total water power worth developing, including that which is already utilized, is estimated at 1.25 million horse-power. This water power is distributed through the valleys of the Rhine, the Rhone, and other rivers, which at mean height carry 1,475 cubic meters of water per second over the Swiss frontier. The average level of this water is 1,130 meters higher on entering than on leaving Swiss territory. A cubic meter of water weighs 1,000 kilogrammes, and a horse-power is 75 meter-kilogrammes per second. Hence this flood of water is theoretically equivalent to $\frac{1{,}475{,}000 \times 1{,}130}{75} = 22$ million horse-power. We will call this the "meteorological" water power, in distinction to the "technical" or practically available water power. In Switzerland the latter is 1.25 million horse-power, or about 5.5 per cent of the power. The ratio is larger in some countries (Norway and Sweden) and smaller in others (Canada), but the Swiss ratio fairly represents the general average, and applies particularly to tropical lands with definite rainy seasons and to the vast mountain region of the Andes.

We shall certainly not underestimate the available water power of the globe if we assume the Swiss ratio to apply everywhere. The volume of water poured into the ocean by the rivers of the whole world is estimated at 31,000 cubic kilometers per year, or one million cubic meters per second, and the mean height of the continents above sea level is 700 meters. Hence the meteorological water power of the globe is about 9,000 million horse-power, and the technical water power is 5.5 per cent of this, or about 500 million horse-power.

The quantity of fuel which this amount of energy can replace will depend on the form in which the energy is used. If it is used in the form of mechanical energy it is more than sufficient to replace all of the fuel now consumed, as the power obtainable from the mineral fuel consumed in 1909 is 270 million horse-power, while the technical water power of the globe is 500 million horse-power. But this superfluity will not long continue, for both the consumption of fuel and the utilization of water power are steadily and rapidly increasing. On closer examination, indeed, the excess proves to be only apparent, for a great deal of fuel is burned in order to produce heat, not mechanical energy. The thermal equivalent of one horse-power is 640 calories per hour, or about 5.5 million calories per year. Hence the available water power of the globe is equivalent to 2.8×10^{15} calories per year, that is to about 40 per cent of the thermal effect of the coal mined in 1909.

Thus we reach the conclusion that all the water power on earth could not furnish a sufficient substitute even for the present consumption of coal. This insufficiency is rapidly increasing and it cannot be annulled by any probable increase of the ratio between meteorological and technical water power, which we have taken as 5.5 per cent.

Very little calculation is required to prove that winds and tides can never play an important part in the energetics of the world, although they may be useful in exceptional cases.

All of the sources of energy heretofore considered, except the tides, we supplied by solar radiation. This fact suggests the possibility of obtaining energy directly from the sun's rays. We will consider the most favorable case, that of a tropical desert, where the effect of the rays is least diminished by clouds and obliquity of incidence.

At the latitude of 20 degrees one square meter of horizontal surface receives annually 1.4 million calories from solar radiation. The thermal equivalent of one horse-power, therefore, is received by an area of 4 square meters, the equivalent of the earth's available water power is received by 2,000 square kilometers, and the equivalent of the world's consumption of coal in 1909 is received by 5,000 square kilometers. The desert of Sahara alone covers an area of 9 million square kilometers. The meteorological conditions for a capture of energy on a vast scale are thus provided. The capture has been attempted, but on a very small scale and by an ineffective method. The sun's rays have been made to furnish mechanical energy by generating steam in boilers. This method involves great losses, and is incapable of high efficiency.

A more promising method consists in employing the solar radiation to form chemical compounds rich in latent energy; the greater part of which could be re gained in the form of heat or electricity by converting these compounds into others, poor in energy. A beginning has been made in the realization of this idea, in laboratory experiments.

This process of capturing the energy of solar radiation is constantly going on, in the vegetable world, on a colossal scale. It will be of interest, therefore, to test its efficiency by an example. In a favorable season one hectare (about 2.5 acres) of good land produces 40 tons of beets, containing 6 tons of sugar. One square meter, therefore, produces 600 grammes of sugar, the combustion of which will yield about 2,000 calories of heat. During the growing season of the beet (May 1 to September 15) one square meter of ground at the latitude of 50 degrees receives the equivalent of 300,000 to 400,000 calories in solar radiation. Hence the proportion of solar radiation that can be captured and utilized in this way is only 0.5 to 0.7 per cent. Nearly the same result is obtained when the wood produced in a forest is substituted for the sugar yielded by a beet field.

Hence a productive area of 3.5 million square kilometers, equal to two thirds of European Russia, would be needed to furnish sufficient fuel to produce the thermal equivalent (7×10^{15} calories) of the fossil fuel consumed in 1909.

With favoring climatic conditions and skilful cultivation the yield here taken as an example can be multiplied many fold. Nevertheless the radiation engineer of the future will be compelled to adopt far more rational methods than those of the most successful agriculturists of to-day, in order to still the energy hunger of his fellow men, without encroaching upon the area required for the production of food. Will he succeed in producing a harvest of energy large enough and cheap enough to constitute a veritable substitute for coal? Upon the answer to this question, which cannot now be given, will depend the fate of our whole civilization, unless the future shall reveal available sources of energy, which are now unknown or but dimly foreseen, such as the immense store of latent atomic energy which produces the phenomena of radioactivity.

* Prof. Georg von dem Borne, in *Deutsche Technik*.

Baffin Land, the largest island of the American Arctic archipelago (area about 236,000 square miles), is also one of the least well known. A tentative delineation of the northern part, but without actual surveys, was made by recent Canadian expeditions under Capt. Bernier, while the eastern coast of the Fox Basin, as shown on our latest maps, depends upon the Eskimo charts published in the narrative of Hall's second Arctic expedition and drawn in 1868. Although Scotch missionaries have been stationed on Cumberland Sound for thirty years, and Scotch traders have lived there and elsewhere on the east coast, no one ever succeeded in crossing the island from east to west until the year 1910, when the feat was accomplished by a young German ornithologist, Bernhard Hantzsch, who unfortunately lost his life on his return journey the following year. A preliminary report of Hantzsch's explorations has just been published in Germany, and a larger work, including all the explorer's journals and notes, is in preparation.

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